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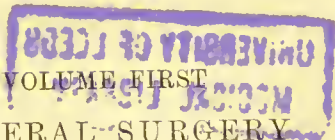
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SURGEON EDINBURGH ROYAL INFIRMARY



VOLUME FIRST
GENERAL SURGERY

*FOURTH EDITION REVISED AND ENLARGED
WITH 297 ILLUSTRATIONS*

EDINBURGH, GLASGOW, AND LONDON

HENRY FROWDE AND HODDER & STOUGHTON

1911



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PREFACE TO FOURTH EDITION

IN the preparation of a new edition of this work, we have adhered to our original plan of endeavouring to furnish a systematic view of the present-day aspects of Surgery in sufficient detail to render it useful to the practitioner, without at the same time carrying it beyond the scope appropriate to a Manual for Students.

We have curtailed as far as possible the discussion of theoretical and debatable matter, and have only described pathological processes in so far as they bear directly on diagnosis and treatment. We have not considered it advisable to describe or to illustrate histological appearances, as these are more appropriately dealt with in a textbook of Pathology.

The descriptions of the Injuries and Diseases of individual tissues and organs have been arranged with a view to facilitate clinical study, and with the same object a brief résumé has been given of the Surgical Anatomy of the tissue or region concerned.

While the general arrangement of the work has not been materially altered, we have thought it advisable to transfer the section on Deformities of the Extremities to the second volume, which deals with regional surgery; and to enable us to furnish a detailed description of operative procedures we have added a third volume on Operative Surgery.

Many of the woodcuts used in the previous editions have

been replaced by process blocks, and a large number of new illustrations have been added.

To our colleagues in the Edinburgh School, and to our other friends who have so generously aided us in providing new illustrations, we desire here to tender our sincere thanks. Their individual contributions are duly acknowledged in the legends to the illustrations. Those illustrations not otherwise acknowledged are from drawings or photographs in our own collections.

To our assistants, Mr. James M. Graham, Mr. Pirie Watson, and Mr. James Lochhead, we desire to acknowledge our indebtedness for much valuable help in the revision of the text, the preparation of illustrations, and in proof-reading. To our publishers we would again express our thanks for their liberality in the matter of illustrations and for other valued assistance.

EDINBURGH, *October* 1911.

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MANUAL OF SURGERY

CHAPTER I

REPAIR

Introduction—The ideal process of repair—Modifications of ideal process
—Repair in individual tissues

INTRODUCTION

To prolong human life and to alleviate suffering are the ultimate objects of scientific medicine. The two great branches of the healing art—Medicine and Surgery—are so intimately related to one another that it is impossible to draw a hard and fast line between them, but for convenience Surgery may be defined as “the art of treating lesions and malformations of the human body by manual operations, mediate and immediate.” To apply his art intelligently and successfully, it is essential that the surgeon should be thoroughly conversant with the normal anatomy and physiology of the body, and with the various pathological processes to which it is liable. Without this knowledge he is unable to recognise such deviations from the normal as result from mal-development, injury, or disease, or rationally to direct his efforts towards the correction or removal of these. And, further, it is not only necessary that he should be familiar with the nature of the various morbid conditions met with in the body, but he must also understand the methods by which nature brings about the repair of these conditions, for it must never be forgotten that the repair of living tissues is a natural and spontaneous process which tends to go on to perfection, except in so far as it is interfered with by external agencies. The rôle of surgery, then, being to correct or remove such extraneous influences as tend to interfere with natural reparative processes, it is necessary that at the outset the student

should clearly understand the natural process of repair in order that his efforts may be directed in harmony therewith.

PROCESS OF REPAIR

The Ideal Process of Repair : Healing by Primary Union.

—The ideal process of natural repair can best be studied as it occurs in a clean-cut wound of the integument, uncomplicated by loss of tissue or by the presence of foreign substances, and more particularly of disease-producing micro-organisms. Such a wound, in virtue of the absence of organisms, is said to be *aseptic*, and furnishes the most favourable conditions possible for the reparative process.

Formation of Granulation Tissue.—The passage of the knife through the tissues is immediately followed by an oozing of blood, which soon coagulates on the cut surfaces. In each of the divided vessels a clot forms, and extends as far as the nearest collateral branch; and on the surface of the wound there is a microscopic layer of bruised and devitalised tissue. If the wound be now closed, the narrow space between its edges is occupied by blood-clot, which consists of red and white corpuscles mixed with a quantity of fibrin, and which forms a temporary uniting medium between the divided surfaces. Soon the capillaries of the part adjacent to the wound begin to dilate and to throw out minute buds and fine processes, which bridge the gap and form a firmer, but still temporary, connection between the two sides. Each bud begins in the wall of the capillary as a small accumulation of granular protoplasm, which gradually elongates into a filament containing a nucleus. This filament either joins with a neighbouring capillary or with a similar filament, and in time these become hollow and are filled with blood from the vessels that gave them origin. In this way a series of young *capillary loops* is formed, the spaces between them being filled by large, irregular nucleated cells, derived from the proliferation of the fixed connective tissue cells of the part, and from the endothelial lining of the newly formed vessels. As these cells are concerned in the production of fibrous tissue they are known as *fibroblasts*. Large multi-nucleated *giant cells* may also be found amongst the fibroblasts, especially if any foreign body, such as a silk ligature, is embedded in the tissues.

Wandering leucocytes, too, are present in the spaces between the capillary loops, but take no direct part in the formation of the new tissue. Their function seems to be the removal of the

red corpuscles and fibrin of the original blood-clot, and this performed, they either pass back into the circulation in virtue of their amœboid movement, or are themselves eaten up by the growing fibroblasts.

These young capillary loops with their supporting cells and fluids constitute *granulation tissue*, which must be looked upon as the fundamental and invariable basis of all tissue repair.

Formation of Cicatricial Tissue.—This temporary granulation tissue is subsequently transformed into *young cicatricial or scar tissue*, its cellular elements disappearing as the fibrous tissue increases in amount. The fibroblasts become enlarged, rounded, and finally spindle-shaped, and produce around them a fibrillated substance which gradually increases in amount and develops into white fibrous tissue. This fibrous tissue assumes an arrangement depending upon the mechanical pull or pressure which happens to be put upon the part. At the same time the capillaries become narrowed and also less numerous.

While these changes are taking place, the surface is being covered over by *epidermis* growing in from the margins of the wound. The cells of the rete Malpighii close to the cut edge sprout on to the surface of the wound, and by their proliferation cover the granulations with a thin pink pellicle. As the epithelium increases in thickness it assumes a bluish hue, and eventually the cells become cornified and the epithelium assumes a greyish-white colour.

In the more highly vascular parts of the body, such as the face, these reparative processes are completed in from three to five days, while in parts where the anastomosis is less free, for example, on the limbs or trunk, they may occupy from a week to ten days.

In course of time the newly formed connective tissue undergoes *cicatricial contraction* by the diminution in size of the blood-vessels and cells and the consolidation of the young white fibrous tissue.

The process of ideal repair being unassociated with infection by micro-organisms, goes on without any interference with the general health of the patient. The temperature remains normal; the circulatory, gastro-intestinal, nervous, and other functions are undisturbed; locally, the part is cool, of natural colour, and free from pain.

This natural process of repair has long been known as "healing by first intention." It takes place without artificial aid from the surgeon, so long as the edges of the wound are

in apposition and extraneous sources of irritation are excluded. It is the type of all reparative processes, the various clinical modifications differing from it only in degree. Reparative processes complicated by extraneous agencies, such as septic infection, show important differences which will be considered later.

Modifications of the Process of Repair.—*Reunion of Parts entirely Separated from the Body.*—Small portions of tissue, such as the end of a finger, the tip of the nose, or a portion of the external ear, completely separated from the body, if accurately replaced and fixed in position, occasionally adhere by primary union.

Healing under a Scab.—When a small superficial wound is exposed to the air, the blood and serum exuded on its surface sometimes dry and form a hard crust or *scab*, which may serve to protect the surface from external irritation in the same way as would a dry pad of sterilised gauze. Under this scab the formation of granulation tissue, its transformation into cicatricial tissue, and the growth of epithelium on the surface, go on uninterruptedly, until in the course of time the crust separates, leaving a scar.

Healing by Blood-clot.—In subcutaneous wounds, for example tenotomy, in amputation wounds, and in wounds made in excising tumours or in operating upon bones, it is impossible accurately and completely to approximate the divided surfaces. The result is that the space left becomes filled with blood-clot, and this acts as a temporary scaffolding in which granulation tissue is built up. Capillary loops grow into the coagulum, and migrated leucocytes from the adjacent blood-vessels destroy the red corpuscles, and are in turn disposed of by the developing fibroblasts, which by their growth and proliferation fill up the gap with young connective tissue. It will be evident that this process only differs from healing by primary union in the amount of blood-clot that is present.

Repair after Loss or Destruction of Tissue.—When no attempt towards approximation of the edges of a wound can be made, either because a considerable portion of tissue has been lost, for example, in excising a tumour implicating the skin, or because of the necessary presence in the wound of a foreign body, such as a drainage tube or gauze packing, the healing process is somewhat modified.

A much greater amount of new tissue is required to fill the gap,—although the process by which this is produced is essentially the same as in the ideal method of repair—namely,

the formation of granulation tissue, and its transformation into young fibrous tissue.

The raw surface is first covered by a layer of coagulated blood and fibrin. An extensive new formation of capillary loops and fibroblasts takes place towards the free surface, and goes on until the gap is filled by a fine velvet-like mass of granulation tissue, and then the process tends to stop. This granulation tissue is gradually replaced by young cicatricial tissue, and the surface is covered by the ingrowth of epithelium from the edges of the skin. This modification of the reparative process can be well studied clinically in a wound which, at the time of the operation, has been packed with gauze. When the plug is introduced, the walls of the cavity consist of raw tissue with numerous oozing blood-vessels. On removing the stuffing on the fifth or sixth day, it is found that the surface is covered with minute, red, papillary projections (*granulations*), and that already the cavity has become smaller, having been filled in from below by the granulations. At the edges, too, the epithelium has proliferated and is covering over the newly formed tissue. On subsequently examining the wound at intervals of a few days, it is found that the granulation tissue gradually increases in amount till the gap is completely filled up, and that coincidently the epithelium spreads in and covers over its surface. In course of time the epithelium thickens, and as the granulation tissue is slowly replaced by young cicatricial tissue, which has a peculiar tendency to contract and so to obliterate the blood-vessels in it, the scar that is left becomes smooth, pale, and depressed. This method of healing is sometimes spoken of as "healing by granulation"—although, as we have seen, it is by granulation that all repair takes place.

Healing by Union of two Granulating Surfaces.—In widely gaping wounds union is sometimes obtained by bringing the two surfaces into apposition after each has become covered with healthy granulations. The exudate on the surfaces causes them to adhere, capillary loops pass from one to the other, and their final fusion takes place by the further development of granulation and cicatricial tissue.

REPAIR IN INDIVIDUAL TISSUES

The process of repair in general having been studied, it will obviate unnecessary repetition later if the modifications of that process as seen in the regeneration of certain of the individual

tissues is now considered. Nature's efforts are always directed towards effecting a complete and perfect restitution to the normal, but her success varies with the tissue involved and the amount of damage it has sustained. Any given tissue can only be replaced from tissue of a similar kind; but while simple structures such as skin, cartilage, bone, periosteum, or tendon have a high power of regeneration, those of a more complex organisation, such as secreting glands, muscle, and the tissues of the central nervous system, are but imperfectly restored. The peripheral nerves, however, are eminently capable of regeneration.

In all tissues the elementary basis of repair is granulation tissue. If any portion of the original structure survives, this granulation tissue is replaced by an imitation of the original tissue, more or less perfect in proportion to the simplicity of its constituent elements. When the original tissue is completely destroyed, or is of a highly specialised structure, simple cicatricial connective tissue fills the gap, or a cavity containing a turbid fluid may persist.

Regeneration of Skin and Connective Tissue.—The mode of regeneration of these tissues has already been described as the type of ideal repair. The more highly organised elements of the skin, such as hair follicles, sweat and sebaceous glands, are imperfectly reproduced; hence the scar remains, smooth, dry, and hairless.

Regeneration of Epithelium.—Epithelium is only reproduced from pre-existing epithelium, and, as a rule, from one of a similar type, although metaplastic transformation of cells of one kind of epithelium into another kind can take place. Thus a granulating surface may be covered entirely by the ingrowing of the cutaneous epithelium from the margins; or islets, originating in surviving cells of sebaceous glands or sweat glands, or of hair follicles, may spring up in the centre of the raw area. Such islets may also be due to the accidental transference of loose epithelial cells from the edges. Even the fluid from a blister, in virtue of the isolated cells of the rete Malpighii which it contains, is capable of starting epithelial growth on a granulating surface. Hairs and nails may be completely regenerated if a sufficient amount of the hair follicles or of the nail matrix has escaped destruction. The epithelium of a mucous membrane is regenerated in the same way as that on a cutaneous surface.

Epithelial cells have the power of living for some time after being separated from their normal surroundings, and of growing

again when once more placed in favourable circumstances. On this fact the practice of skin-grafting is based.

Repair of Tendons.—When a tendon is divided, the end nearer the muscle fibres is drawn away from the other, leaving a gap which is speedily filled by blood-clot. In the course of a few days this clot becomes permeated by granulation tissue, the fibroblasts of which are derived from the sheath of the tendon, the surrounding connective tissue, and probably also from the divided ends of the tendon itself. These fibroblasts ultimately develop into typical tendon cells, and the fibres which they form constitute the new tendon fibres. In the course of this reparative process it is not uncommon for the tendon and its sheath to become adherent, which leads to impaired movement and stiffness.

Repair of Cartilage.—Solutions in continuity of cartilage are usually repaired by ordinary cicatricial fibrous tissue. This takes place, for example, when a portion of articular cartilage is divided by incision or by a fracture implicating the articular end of a bone.

In other cases, such as in fractures of costal cartilage or of the cartilages of the larynx, the cicatricial tissue is ultimately replaced by bone.

It is, however, possible for a metaplastic transformation of connective-tissue cells into cartilage cells to take place, the characteristic hyaline matrix being secreted by the new cells. This is sometimes observed as an intermediary stage in the healing of fractures, especially in young bones. It may also take place in the regeneration of lost portions of cartilage, provided the new tissue is so situated as to constitute part of a joint and to be subjected to pressure by an opposing cartilaginous surface. This is illustrated by what takes place after excision of joints where it is desired to restore the function of the articulation. By carrying out movements between the constituent parts, the fibrous tissue covering the ends of the bones becomes moulded into shape, its cells take on the characters of cartilage cells, and forming a matrix, so develop a new cartilage.

Conversely, it is observed that when articular cartilage is no longer subjected to pressure by an opposing cartilage, it tends to be transformed into fibrous tissue, as may be seen in deformities attended with displacement of articular surfaces, such as hallux valgus and club-foot.

Repair of Bone.—The repair of bone is most conveniently considered in relation to fractures. The steps in the reparative

process are practically identical whether the bone has been broken by external violence, or divided in the operation of osteotomy, in resection of a segment of the bone, or in excision of a joint.

Repair of Muscle.—Neither unstriped nor striped muscle seems to be capable of being regenerated to any but a moderate degree. If the ends of a divided muscle are at once brought into apposition by stitches, primary union takes place with a minimum of intervening fibrous tissue. The nuclei of the muscle fibres in close proximity to this young cicatricial tissue proliferate, and a few new muscle fibres may be developed, but any gross loss of muscular tissue is replaced by a fibrous cicatrix. It would appear that portions of muscle transplanted from animals to fill up gaps in human muscle are similarly replaced by fibrous tissue. When a muscle is paralysed from loss of its nerve-supply and undergoes complete degeneration, it is not capable of being regenerated, even should the integrity of the nerve be restored, and so its function is permanently lost.

The *Repair of Blood-vessels* is described at p. 274.

Regeneration of Secretory Glands.—The regeneration of secretory glands, such as the salivary glands, liver, and kidney, is usually incomplete. The greater part of a gap left in such organs is filled by cicatricial tissue, but in some—for example, the liver and kidney—the epithelial cells of the remaining glandular tissue proliferate, and a certain degree of regeneration takes place.

Regeneration of Intestine and other Composite Structures.—Composite structures like the intestine, the œsophagus, the bladder, or the urethra, are repaired by the formation of cicatricial tissue, each constituent element behaving after the manner of its kind. Thus the muscular and glandular tissues are not reproduced, while the fibrous, vascular, and lining epithelial elements are.

Regeneration of Nerve Tissues.—There is no trustworthy evidence that regeneration of the tissues of the brain or spinal cord in man ever takes place. Any loss of substance is replaced by cicatricial tissue.

The *Regeneration of Peripheral Nerves* is described at p. 351.

CHAPTER II

CONDITIONS WHICH INTERFERE WITH REPAIR

Want of rest—Irritation—Unhealthy tissues—Pathogenic bacteria.
SURGICAL BACTERIOLOGY—Introduction—General characters of bacteria—Classification of bacteria—Conditions of bacterial life—Pathogenic powers of bacteria—Results of bacterial growth—Death of bacteria—Immunity—Antitoxic sera—Identification of bacteria—Pyogenic Bacteria. LEUCOCYTOSIS. THE TEMPERATURE IN SURGICAL DISEASES.

THE general process of ideal repair, and its modifications in the regeneration of the different tissues that have been studied, are liable to be interrupted or completely arrested by various extraneous influences which it is the duty of the surgeon to prevent or remove.

Of such conditions the first is *want of rest*. “The first and great requisite for the restoration of injured parts is rest,” said John Hunter; and physiological and mechanical rest as the chief of natural therapeutic agents was the theme of John Hilton’s classical work. By “rest,” in this connection, is meant not merely a state of physical repose, but in addition as complete cessation of all physiological and mechanical function as is possible. A tuberculous joint, for example, must be enclosed in splints in such a way as to prevent all movement of its constituent bones; or an inflamed eye must be protected from the light, in addition to having its movements arrested.

Another fertile source of interference with repair in surgical wounds is *irritation*, either by mechanical agents such as rough, unsuitable dressings, bandages, or ill-fitting splints; or by chemical agents in the form of strong lotions or other applications.

An *unhealthy or devitalised condition of the patient’s tissues* also hinders the reparative process. Bruised or lacerated skin heals less kindly than skin cut with a smooth, sharp instrument; and persistent venous congestion of a part, such as occurs, for example, in the leg when the veins are varicose, by preventing the access of healthy blood, tends to delay the healing of open

wounds. The existence of grave constitutional disease, such as Bright's disease, diabetes, syphilis, scurvy, or alcoholism, also impedes healing.

Infection by disease-producing micro-organisms or *pathogenic bacteria* is, however, the most potent factor in disturbing the natural process of repair in surgical wounds.

SURGICAL BACTERIOLOGY

Within recent years the whole science of pathology has been revolutionised by the knowledge which has accumulated regarding the nature of micro-organisms, and their relation to disease. So much has bacteriology come to dominate every department of surgery in particular, that it is now the standpoint from which nearly all surgical questions have to be considered. In no department of medical science has so much progress been made, or such a wealth of information and literature arisen, in a corresponding period of time. It is therefore necessary that we should here confine our attention to such aspects of the subject as have a direct surgical bearing.

The term *sepsis* as now used in clinical surgery no longer retains its original meaning as synonymous with "putrefaction," but is employed to denote all conditions in which bacterial infection has taken place, and more particularly those in which pyogenic bacteria are present. In the same way the term *aseptic* conveys the idea of freedom from all forms of bacteria, putrefactive or otherwise; and the term *antiseptic* is used to denote a power of counteracting bacteria and their products.

General Characters of Bacteria.—The term *bacteria* is employed in a generic sense to include all the forms of minute vegetative organisms of which the science of bacteriology treats, and is to be accepted as synonymous with such terms as micro-organisms, microbes, and germs.

A *bacterium* consists of a finely granular mass of protoplasm, enclosed in a thin, gelatinous envelope. Many forms are motile—some in virtue of fine thread-like flagella, and others through contractility of the protoplasm. The great majority multiply by simple fission, each parent cell giving rise to two daughter cells, and this process goes on with such extraordinary rapidity, that it has been computed that in twenty-four hours from one individual bacterium seventeen millions of similar cells may be produced. Other varieties, particularly bacilli, are propagated by the formation of *spores*, but as most spore-forming bacteria give rise to only one spore, this is rather a process of rejuven-

escence than of multiplication. A spore is a minute mass of protoplasm surrounded by a dense, tough membrane, developed in the interior of the parent cell. Spores are remarkable for their tenacity of life, and for the resistance they offer to the action of heat and chemical germicides.

Bacteria are most conveniently classified according to their shapes. Thus we recognise (1) those that are globular—*cocci*; (2) those that resemble a rod—*bacilli*; (3) the spiral or wavy forms—*spirilla*.

Cocci or *micrococci* are minute round bodies, averaging about $1\ \mu$ in diameter. The great majority are non-motile. They multiply by fission; and when they divide in such a way that the resulting cells remain in pairs, are called *diplococci*, of which the bacteria of gonorrhœa and pneumonia are examples (Fig. 4). When they divide irregularly and form grape-like bunches, they are known as *staphylococci*, and to this variety the commonest pyogenic or pus-forming organisms belong (Fig. 1). When division takes place only in one axis, so that long chains are formed, the term *streptococcus* is applied (Fig. 2). Streptococci are met with in erysipelas and various other inflammatory and suppurative processes of a spreading character.

Bacilli are rod-shaped bacteria, usually at least twice as long as they are broad. Some multiply by fission, others by sporulation. Some forms are motile, others are non-motile. Tuberculosis, tetanus, anthrax, and many other surgical diseases are due to different forms of bacilli.

Spirilla are long, slender, thread-like cells, more or less spiral or wavy. Some move by a screw-like contraction of the protoplasm, some by flagella. The spirochæte associated with syphilis (Fig. 36) is the most important member of this group.

Conditions of Bacterial Life.—The first essential to the growth and development of bacteria is a suitable food-supply in the form of proteids and carbohydrates, which complex organic substances they break up, in the act of nourishing themselves, into simpler elements. Certain mineral salts are also necessary. An alkaline medium favours bacterial growth; and moisture is a necessary condition, but spores can survive the want of water for much longer periods than fully developed bacteria. The necessity for oxygen varies in different species. Those which, like the *bacillus proteus vulgaris*, can only flourish in its presence are known as *aërobic bacilli*, or *aërobes*; those, such as the *bacillus* of tetanus and of malignant œdema,

which will not live in the presence of oxygen, are spoken of as *anaërobic*. The great majority of bacteria, however, while they prefer oxygen, are able to live without it, and are called *facultative anaërobic*.

The most suitable temperature for bacterial life is from 95° to 102° F., roughly that of the human body. Extreme or prolonged cold paralyzes but does not kill micro-organisms. Few, however, survive being raised to a temperature of 134½° F. Boiling for ten to twenty minutes will kill not only bacteria, but even their most resistant spores. Direct sunlight, electric light, or even diffuse daylight, is inimical to the growth of bacteria.

Pathogenic Properties of Bacteria.—We are now only concerned with pathogenic bacteria—that is, bacteria capable of producing disease in the human subject. This capacity depends upon two sets of factors—(1) certain features peculiar to the invading bacteria, and (2) others peculiar to the host. Many bacteria have only the power of living upon dead matter, and are known as *saprophytes*. Such as do flourish in living tissue are, by distinction, known as *parasites*. The power a given parasitic micro-organism has of multiplying in the body and giving rise to disease is spoken of as its *virulence*, and this varies not only with different species, but in the same species at different times and under varying circumstances. The actual number of organisms introduced is also an important factor in determining their pathogenic power. Healthy tissues can resist the invasion of a certain number of bacteria of a given species, but when that number is exceeded, the organisms get the upper hand and disease results. If organisms gain access directly to the blood-stream, they as a rule produce their effects more certainly and with greater intensity than when they are introduced into the tissues.

Further, the virulence of an organism is modified by the condition of the patient into whose tissues it is introduced. So long as a person is in robust health, the tissues are able to resist the attacks of moderate numbers of most bacteria. Any lowering of the vitality of the individual, however, either locally or generally, at once renders him more susceptible to infection. Thus bruised or torn tissue is much more liable to infection with pus-producing organisms than tissues clean-cut with a knife; also, after certain diseases, the liability to infection by the organisms of diphtheria, pneumonia, or erysipelas is much increased. Even such slight depression of vitality as results from bodily fatigue, or exposure to cold and damp, may be

sufficient to turn the scale in the battle between the tissues and the bacteria. Age is an important factor in regard to the action of certain bacteria. Young subjects are attacked by diphtheria, tuberculosis, acute osteomyelitis, and some other diseases with greater frequency and severity than those of more advanced years.

In different races, localities, environments, and seasons, the pathogenic powers of certain organisms, such as those of erysipelas, diphtheria, and acute osteomyelitis, vary considerably.

There is evidence that a *mixed infection*—that is, the introduction of more than one species of organism, for example, the tubercle bacillus and a pyogenic staphylococcus—increases the severity of the resulting disease. If one of the varieties gain the ascendancy, the poisons produced by the others so devitalise the tissue cells, and diminish their power of resistance, that the virulence of the most active organism is increased. On the other hand, there is reason to believe that the products of certain organisms antagonise one another—for example, an attack of erysipelas may effect the cure of a patch of tuberculous lupus.

Lastly, in patients suffering from chronic wasting diseases, bacteria may invade the internal organs by the blood-stream in enormous numbers and with great rapidity, during the period of extreme debility which shortly precedes death. The discovery of such collections of organisms on post-mortem examination may lead to erroneous conclusions being drawn as to the cause of death.

Results of Bacterial Growth.—Some organisms, such as those of tetanus and erysipelas, and certain of the pyogenic bacteria, show little tendency to pass far beyond the point at which they gain an entrance to the body. Others, on the contrary,—for example, the tubercle bacillus and the organism of acute osteomyelitis,—although frequently remaining localised at the seat of inoculation, tend to pass to distant parts, lodging in the capillaries of joints, bones, kidney, or lungs, and there producing their deleterious effects.

In the human subject, multiplication in the blood-stream does not occur to any great extent, and organisms can seldom be detected for diagnostic purposes in the blood, either on microscopic examination or by culture.

It is by the vital changes they bring about in the parts where they settle that micro-organisms disturb the health of the patient. In deriving nourishment from the complex organic compounds in which they flourish, the organisms evolve,

probably by means of a ferment, certain chemical products known as *toxins*. When these poisons are absorbed into the general circulation, they give rise to certain groups of symptoms—such as rise of temperature, associated circulatory and respiratory derangements, interference with the gastro-intestinal functions and also with those of the nervous system—which go to make up the condition known as blood-poisoning, toxæmia, or *bacterial intoxication*. In addition to this, certain bacteria produce toxins that give rise to definite and distinct groups of symptoms—such as the convulsions of tetanus, or the paralyses that follow diphtheria.

Local lesions also, of an inflammatory, suppurative, or ulcerative character, result from the action of certain organisms and their products, as in tuberculosis, typhoid fever, anthrax, and diphtheria.

Death of Bacteria.—Under certain circumstances, it would appear that the accumulation of the toxic products of bacterial action tends to interfere with the continued life and growth of the organisms themselves, and in this way the natural cure of certain diseases is brought about. Outside the body, bacteria may be killed by starvation, by want of moisture, by being subjected to high temperature, or by the action of certain chemical agents, of which carbolic acid and the perchloride and biniodide of mercury are the most powerful.

Immunity.—It has long been known that some persons are insusceptible to infection by certain diseases, from which they are said to enjoy a *natural immunity*. It is also well established in the case of many acute diseases—it is probably true of all—that one attack protects the patient, for a time at least, from a second attack. This is known as an *acquired immunity*. It would appear that immunity is acquired by the introduction into the system of certain products of living cells, which are antagonistic either to toxins or to the vital activity of bacteria. These substances, known as antitoxins, are formed in the course of the disease by certain cells of the body, and probably represent a normal constituent of such cells, produced in increased quantity. The chief rôle in the formation of these antitoxin bodies is played by the leucocytes, which, as Metchnikoff showed, have the power of ingesting bacteria. To this process he gave the name of *phagocytosis*, and he recognised two forms of *phagocytes*: (1) the *microphages*, which are the polymorphonuclear leucocytes of the blood; and (2) the *macrophages*, which include the larger hyaline leucocytes, endothelial cells, and connective-tissue corpuscles. The phagocytes are attracted to

the bacteria by *chemiotaxis*, and in the process of phagocytosis, when the cells are broken up, certain digestive ferments called *opsonins*, or *alexines*, are given off by the leucocytes, and enter the blood serum. These opsonins act on the bacteria by a process comparable to narcotisation, and render them a suitable prey for the phagocytes, which then ingest and destroy them. In the absence of opsonins the phagocytes are powerless against the bacteria. When the blood serum contains a sufficient quantity of opsonin to affect all the bacteria present, the disease is cured, and so long as this proportion is maintained the patient is immune.

In normal blood there is a certain quantity of opsonin, capable of dealing with a proportionate number of a particular organism, for example, the tubercle bacillus. This proportion is spoken of as the *opsonic index* of the blood. For clinical purposes the opsonic index is estimated by comparing the number of organisms ingested by, say, one hundred phagocytes from a normal blood—usually that of the observer—with the number ingested by the same number of phagocytes from the blood of the patient under investigation. The index of the normal blood is taken as unity, and that of the diseased blood is represented in decimal fractions of 1. When the opsonic index is below the normal for the patient, he is said to be in a *negative phase*, the phagocytes being then less capable of dealing with bacteria; when it rises above the level at which it originally stood, he is in the *positive phase*, and the phagocytic power is correspondingly improved.

The practical application of these facts is that vaccines and antibacterial sera should not be given while a patient is in a negative phase, as a certain amount of the opsonin in the blood is used up in neutralising the substances injected, and this may reduce the opsonic index to such an extent that the vaccines themselves become dangerous. If given during a positive phase, the vaccines raise the opsonic index and stimulate the phagocytes, so enabling them to deal with the organisms causing the disease.

Artificial Immunity.—Immunity from certain diseases may be produced by artificial inoculation with the products of the organisms that cause them.

This *artificial immunity* may be induced in one of two ways—(a) by injecting into an animal a series of non-lethal doses of an organism or its toxins; or (b) by injecting the serum of an animal highly immunised by the previous method. The latter is the principle on which the modern antitoxin method

of treatment is based, and it may act either against specific toxins as in the case of the anti-diphtheric and the anti-tetanus sera (*antitoxic sera*), or against specific organisms, as in the anti-streptococcic serum (*anti-microbic sera*).

The *antitoxic sera* are produced by a process of which the following are the essential steps:—(1) a powerful toxin is obtained from artificial cultures of a highly virulent organism. (2) The power of this toxin is estimated by experimental injections into animals of known weight, until a standard of toxicity is obtained; (3) a large animal—for example, the horse—after being rendered immune by gradually increasing doses of this toxin, is bled aseptically, and the serum after separating is ready for use, 0·5 per cent. of carbolic acid being added to prevent decomposition. (4) By experiments on animals the immunising value (“unit of immunity”) of this serum is then obtained, and the clinical dose determined.

Clinical Use of Antitoxic Sera.—Each antitoxic serum has its own appropriate dose depending upon the value of its unit of immunity. Every precaution must be taken to prevent organismal contamination of the serum or of the apparatus by means of which it is injected. Syringes are so made that they can be sterilised by boiling. The best situations for injection are under the skin of the abdomen, the thorax, or the buttock, and the skin should be purified at the seat of puncture. If the bulk of the full dose is large, it should be divided and injected into different parts of the body, not more than 20 c.c. being injected at one place. The immunity produced by injections of antitoxic sera lasts only for a comparatively short time, seldom longer than a few weeks.

Vaccine Treatment.—Another outcome of the study of phagocytosis in relation to the production of immunity is the vaccine method of treating bacterial infections, introduced by A. E. Wright. This consists in injecting, while the disease is still active, specially prepared dead cultures of the causative organisms, and is based on the fact that these “vaccines” raise the opsonic power of the fluids of the body, and so render the bacteria in the tissues less able to resist the attacks of the phagocytes. The method is most successful when the vaccine is prepared from organisms isolated from the patient himself, but when this is impracticable, or takes a considerable time, laboratory-prepared “stock” vaccines may be used.

The following are the essential steps in the preparation of the vaccine: a pure culture of the organism is made on a suitable medium, such as agar or blood-agar; after eighteen or

twenty-four hours the growth is washed in normal saline solution, and killed by heat; the emulsion thus obtained is "standardised" by estimating the number of dead bacteria in a given volume, and the dose of this particular vaccine is thus determined. The number of bacteria constituting a dose varies from 250 millions to 500 millions.

Before using the vaccine, the opsonic index may be taken to make certain that the patient is not in a negative phase, and a small dose is then injected into the subcutaneous tissue, a part being selected which is not liable to pressure, as there is sometimes a considerable local reaction. The entrance of the vaccine usually induces a fall in the opsonic index (negative phase), but if the treatment is going to be successful, this is soon followed by a rise above the original level (positive phase), and the local, as well as the general, condition of the patient shows signs of improvement. Repeated doses may be necessary at intervals of a few days, care being taken that the injections are not made while a negative phase is in progress. While the estimation of the opsonic index before each injection may be supposed to render the treatment safer and more certain, it is not always practicable, and in many cases can be dispensed with, provided always the patient is not obviously worse at the time.

The vaccine treatment has been successfully employed for various tuberculous lesions, in pyogenic infections such as acne, boils, sycosis, streptococcal, pneumococcal, and gonococcal conditions, in infections of the accessory air sinuses, and in other diseases caused by bacteria.

Identification of Bacteria.—In identifying different organisms, various facts regarding the morphology and life-history of bacteria are made use of. Thus, by means of the microscope the general histological characters may be studied after staining with certain aniline dyes. Again, different organisms vary in their behaviour on such artificial culture-media as gelatin, agar-agar, bouillon, potato, etc., with regard to the rapidity and direction of growth; the colour and smell of the growing colonies; and the effect these have upon the medium in which they grow, some species evolving gases, others changing the chemical reaction of the medium. Variations also occur depending on the temperature at which the organisms are incubated, the presence or absence of oxygen, and other like conditions. Lastly, by inoculation in animals of different species and in different tissues, information valuable for the purpose of diagnosis may be obtained.

PYOGENIC BACTERIA

From the point of view of the surgeon the most important varieties of micro-organisms are those that cause inflammation and suppuration—the *pyogenic bacteria*. This group includes a great many species, and these are so widely distributed that they are to be met with under all conditions of everyday life.

The nature of the inflammatory and suppurative processes will be considered in detail later; suffice it here to say that

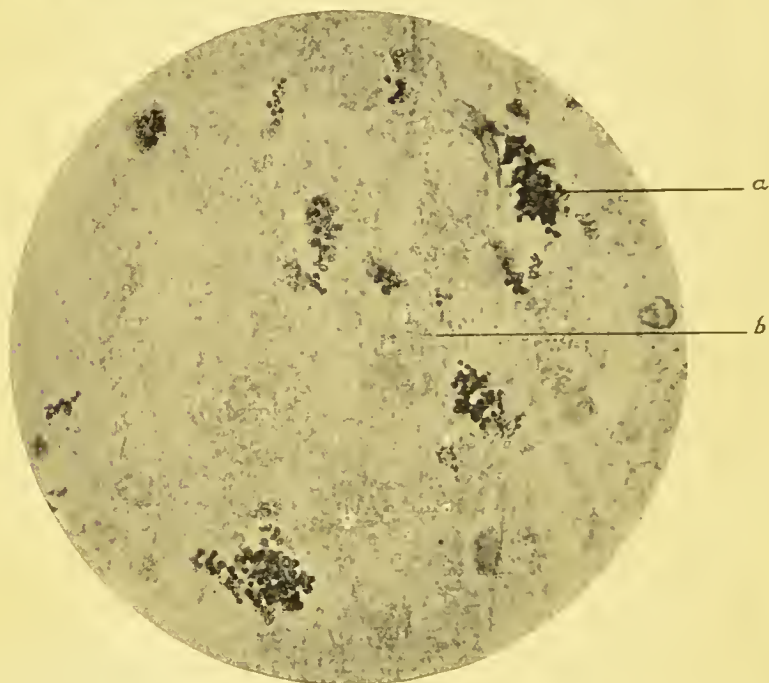


FIG. 1.—*Staphylococcus aureus* in Pus from case of Osteomyelitis.
× 1000 diam.

a = Masses of staphylococci.

b = Altered and degenerated pus cells.

they are brought about by the action of one or other of the organisms that we have now to consider.

It is found that the *staphylococci*, which cluster into groups, tend to produce localised lesions; while the chain-forms—*streptococci*—give rise to diffuse, spreading conditions. Many varieties of pyogenic bacteria have now been differentiated, the best known being the *staphylococcus aureus*, the *streptococcus*, and the *bacillus coli communis*.

Staphylococcus Aureus.—This is the commonest organism found in localised inflammatory and suppurative conditions. It varies greatly in its virulence, and is found in such widely different conditions as skin pustules, boils, carbuncles, and some acute inflammations of bone. As seen by the microscope it occurs in grape-like clusters, fission of the individual cells taking place irregularly (Fig. 1). It grows readily in artificial media, such as agar, on the surface of which it forms a

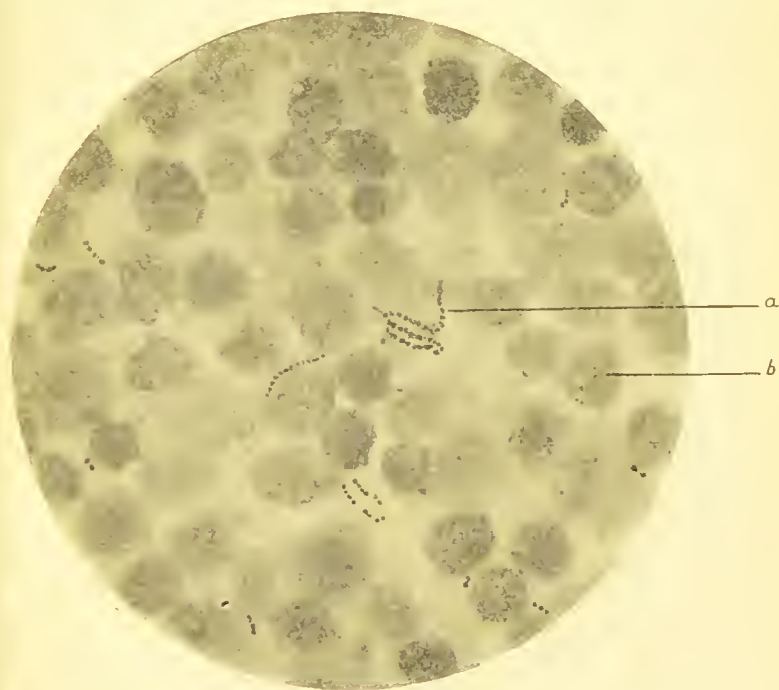


FIG. 2.—Streptococci in Pus from case of Diffuse Cellulitis.
× 1000 diam.

a = Chains of streptococci.

b = Pus cells.

brilliant orange film, or on gelatin, which it liquefies, the organisms forming an orange-yellow deposit at the bottom of the tube—hence the term *aureus*. It is of high vitality, and resists more prolonged exposure to high temperatures than most non-sporing bacteria. It is capable of lying latent in the tissues for long periods, for example in the marrow of long bones, and of again becoming active and causing a fresh outbreak of suppuration. This organism is widely distributed: it is found on the skin, in the mouth, and in other situations in

the body, and as it is present in the dust of the air and on all objects upon which dust has settled, it is a constant source of infection unless means are taken to exclude it from wounds.

The *staphylococcus albus* is much less common than the aureus, but has the same properties and characters, save that its growth on artificial media assumes a white colour. It is the common cause of stitch abscesses, the skin being its normal habitat.

Streptococcus Pyogenes.—This organism also varies greatly in

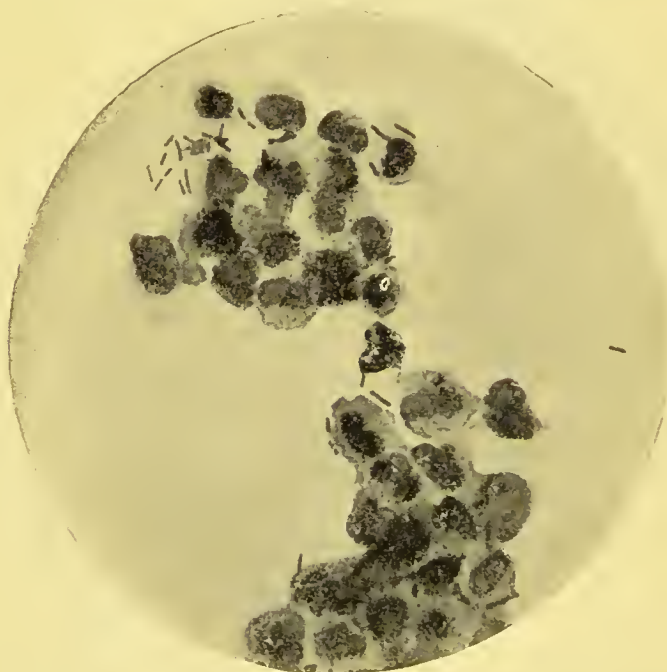


FIG. 3.—*Bacillus coli communis* in Pus from Abdominal Abscess.
×1000 diam.

its virulence, but the conditions that determine the variations are as yet imperfectly understood. In some instances—for example, in erysipelas—it causes a sharp attack of acute spreading inflammation, which soon subsides without showing any tendency to end in suppuration; under other conditions it gives rise to a generalised infection which rapidly proves fatal. The streptococcus has less capacity of liquefying the tissues than the staphylococcus, so that pus formation takes place more slowly. At the same time its products are very potent in

destroying the tissues in their vicinity, and so interfering with the exudation of leucocytes which would otherwise exercise their protective influence. Streptococci invade the lymph spaces, and are associated with acute spreading conditions such as phlegmonous or erysipelatous inflammations and suppurations, lymphangitis and suppuration in lymphatic glands, and inflammation of serous and synovial membranes, also with a form of septic pneumonia which is prone to follow on severe

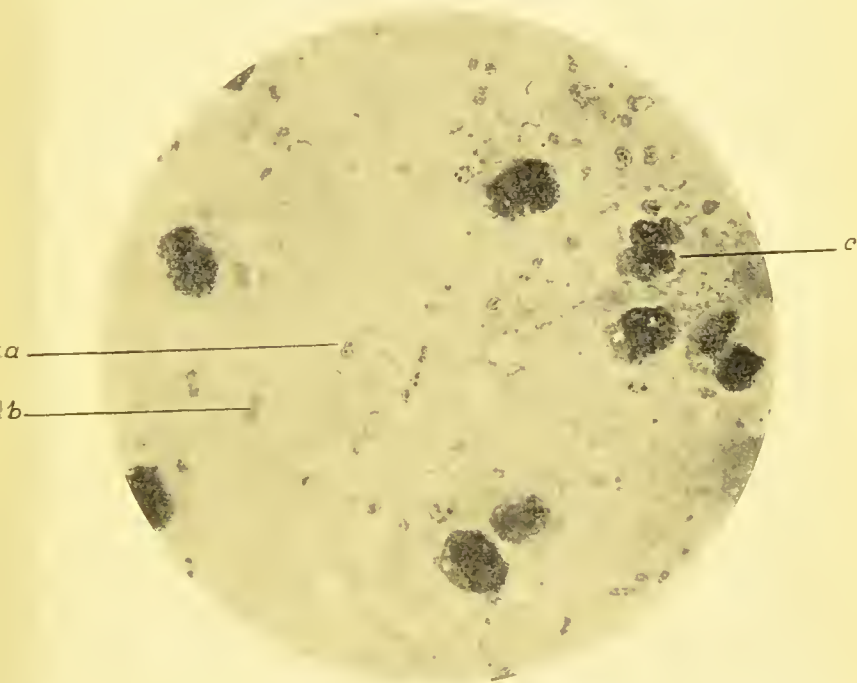


FIG. 4.—Fraenkel's Pneumococci in Pus from Empyema following Pneumonia. $\times 1000$ diam. Stained with Muir's capsule stain.

a = Pneumococci with capsule.
c = Pus cells.

b = Degenerated pneumococci, only the capsule remaining.

operations in the mouth and throat. Streptococci are also concerned in the production of spreading gangrene and pyæmia.

Division takes place in one axis, so that chains of varying length are formed (Fig. 2). It is less easily cultivated in artificial media than the staphylococcus; it forms a whitish growth and does not liquefy gelatin.

Bacillus Coli Communis.—This organism, which is a normal inhabitant of the intestinal tract, shows a great tendency to

invade any organ or tissue whose vitality is lowered. It is causatively associated with such conditions as peritonitis and peritoneal suppuration resulting from strangulated hernia, appendicitis, or perforation in any part of the alimentary canal. In cystitis, pyelitis, abscess of the kidney, suppuration in the bile ducts or liver, and in many other abdominal conditions, it plays a most important part. The discharge from wounds infected by this organism has usually a fœtid, or even a fæcal odour, and often contains gases resulting from putrefaction.

It is a small rod-shaped organism with short flagella, which render it motile (Fig. 3). It closely resembles the typhoid bacillus, but is distinguished from it by its behaviour in artificial culture media.

Pneumo-bacteria.—Two forms of organism are associated with pneumonia — *Fraenkel's pneumococcus* (one of the diplococci) (Fig. 4), and *Friedländer's pneumo-bacillus* (a short rod-shaped form). One or other of these is frequently met with in inflammations of the serous and synovial membranes, in suppuration in the liver, and in various other inflammatory and suppurative conditions.

Bacillus Typhosus.—This organism has been found in pure culture in suppurative conditions of bone, of cellular tissue, and of internal organs, especially during convalescence from typhoid fever. Like the staphylococcus it is capable of lying latent in the tissues for long periods.

Other Pyogenic Bacteria.—It is not necessary to do more than name some of the other organisms that are known to be pyogenic, such as the bacillus pyocyaneus, which is found in green and blue pus; the micrococcus tetragenus; the gonococcus; actinomyces; the glanders bacillus, and the tubercle bacillus. Most of these will receive further mention in connection with the diseases to which they give rise.

Leucocytosis.—Recent investigations have shown that most bacterial diseases, as well as certain other pathological conditions, are associated with an increase in the number of leucocytes in the blood throughout the entire circulatory system. This condition of the blood, which is known as *leucocytosis*, is believed to be due to an excessive output and rapid formation of leucocytes by the bone marrow, and it probably has as its object the arrest and destruction of the invading organisms or toxins. To increase the resisting power of the system to pathogenic organisms, an artificial leucocytosis may be induced by subcutaneous injection of a solution of nucleinate of soda (16 minims of a 5 per cent. solution).

The *normal* number of leucocytes per cubic millimetre varies in different individuals, and in the same individual under different conditions, from 5000 to 10,000. It is generally accepted that 7500 is a

normal average, and that anything above 12,000 is to be considered abnormal. When leucocytosis is present, the number may range from 12,000 to 30,000 or even higher; 40,000 is looked upon as a high degree of leucocytosis. According to Ehrlich, the following may be taken as the standard proportion of the various forms of leucocytes in normal blood: polynuclear neutrophile leucocytes, 70 to 72 per cent.; lymphocytes, 22 to 25 per cent.; eosinophile cells, 2 to 4 per cent.; large mononuclear and transitional leucocytes, 2 to 4 per cent.; mast-cells, 0·5 to 2 per cent.

In estimating the clinical importance of a leucocytosis, it is not sufficient merely to count the aggregate number of leucocytes present. A differential count must be made to determine which variety of cells is in excess. In the majority of surgical affections attended with leucocytosis it is chiefly the granular polymorpho-nuclear neutrophile leucocytes that are in excess (*ordinary leucocytosis*). In some cases, and particularly in parasitic diseases such as trichiniasis and hydatid disease, the eosinophile leucocytes also show a proportionate increase (*eosinophilia*). The term *lymphocytosis* is applied when there is an increase in the number of circulating lymphocytes, as occurs, for example, in lymphatic leucæmia, and in certain cases of syphilis.

Leucocytosis is met with in nearly all the acute infective diseases, such, for example, as erysipelas, diphtheria, pneumonia, scarlet fever, and in general septic infections. It is also present in acute pyogenic inflammatory affections, particularly in those attended with suppuration—for example, peritonitis, appendicitis, abscesses in joints and in internal organs. In some cases of malignant disease the number of leucocytes is increased to 15,000 or 20,000. A few hours after a severe hæmorrhage also there is usually a leucocytosis of from 15,000 to 30,000, which lasts for three or four days (Lyon). In cases of hæmorrhage the leucocytosis is increased by infusion of fluids into the circulation. After all operations there is at least a transient leucocytosis (*post-operative leucocytosis*) (F. I. Dawson).

The degree of leucocytosis is, as a rule, proportionate to the extent of the local lesion, and to the systemic reaction which the local lesion excites. It is to be borne in mind, however, that in very acute septic conditions the extreme virulence of the toxins may prevent the leucocytes reacting, and leucocytosis may be absent. The absence of leucocytosis in a disease in which it is usually present is therefore to be looked upon as a grave omen, particularly when the general symptoms are severe.

The leucocytosis begins soon after the infection manifests itself—for example, by shivering, rigor, or rise of temperature. The number of leucocytes rises somewhat rapidly, increases while the condition is progressing, and remains high during the febrile period, but there is no constant correspondence between the number of leucocytes and the height of the temperature. The arrest of the inflammation and its resolution are accompanied by a fall in the number of leucocytes, while the occurrence of suppuration is attended with a further increase in their number.

In interpreting the "blood count," it is to be kept in mind that a *physiological leucocytosis* occurs within three or four hours of taking a meal, especially one rich in proteids, from 1500 to 2000 being added to the normal number. In this *digestion leucocytosis* the increase is chiefly in the polynuclear neutrophile leucocytes. Immediately before and after delivery, particularly in primiparæ, there is usually a moderate degree of leucocytosis. If the labour is normal and the puerperium uncomplicated,

the number of leucocytes regains the normal in about a week. Lactation has no appreciable effect on the number of leucocytes. In new-born infants the leucocyte count is abnormally high, ranging from 15,000 to 20,000. In children under one year of age, the normal average is from 10,000 to 20,000.

Absence of Leucocytosis—Leucopenia.—In certain infective diseases the number of leucocytes in the circulating blood is abnormally low—3000 or 4000—and this condition is known as *leucopenia*. It occurs in typhoid fever, especially in the later stages of the disease; in tuberculous lesions—for example, tuberculous peritonitis, pleurisy, osteitis, or periostitis, when unaccompanied by suppuration; in malaria, and in most cases of uncomplicated influenza. The occurrence of leucocytosis in any of these conditions is to be looked upon as an indication that a mixed infection has taken place, and that some suppurative process is present.

The absence of leucocytosis in some cases of virulent septic poisoning has already been referred to.

From what has been said it will be evident that numerous fallacies have to be guarded against in estimating the clinical importance of leucocytosis, and that too much reliance must not be placed upon a single observation, particularly in emergency cases. Whenever possible a series of observations should be made, the blood being examined about four hours after meals, and about the same hour each day.

The clinical significance of the blood count in individual diseases will be further referred to later.

The Iodine or Glycogen Reaction.—The leucocyte count may be supplemented by staining films of the blood with a watery solution of iodine and potassium iodide. In all advancing purulent conditions, in septic poisonings, in pneumonia, and in cancerous growths associated with ulceration, a certain number of the polynuclear leucocytes are stained of a brown or reddish-brown colour, due to the action of the iodine on some substance in the cells of the nature of glycogen. This reaction is absent in serous effusions, in unmixed tuberculous infections, in uncomplicated typhoid fever, and in the early stages of cancerous growths.

THE TEMPERATURE IN SURGICAL DISEASES

It may be convenient here to study some of the variations in temperature met with in different forms of surgical disease.

A marked raising of the general temperature of the body is one of the most constant and important concomitants of all infective conditions, and the temperature chart forms a fairly reliable index of the state of the patient. The rise of temperature is due to the absorption into the circulation of bacterial products which interfere with the special nerve-centres in the medulla that regulate the balance between the production and the loss of body heat.

Clinically the temperature is estimated by means of a self-registering thermometer placed, for from one to five minutes, in close contact with the skin in the axilla; or the temperature may be taken in the mouth. Sometimes the thermometer is inserted into the rectum, where, however, the temperature is normally 3° F. higher than in the axilla.

In health the temperature of the body is maintained at a mean of about 98.4° F. (37° C.) by the heat-regulating mechanism. The temperature varies from hour to hour even in health. It reaches its maximum between four and eight in the evening, when it may rise to 99° F., and

is at its lowest between four and six in the morning, when it may be about 97° F.

On reading and interpreting a temperature chart in disease, therefore, it is necessary to make allowance for this normal variation, and it is interesting to observe in this connection that an hourly chart of a case of acute septic infection runs parallel with the normal curve.

It is also worthy of note that the temperature is much more easily disturbed in children than in adults, and may become markedly elevated (104° or 105° F.) from comparatively slight causes; while in the aged it is less liable to change, so that in them a rise to 103° or 104° F. is to be looked upon as indicating a high state of fever.

It is rare for a patient to live if the temperature remains for any length of time above 106° F., although some extraordinary cases are on record in which it has reached as high as 116° F. without proving fatal.

A sudden rise of temperature is usually associated with a feeling of chilliness down the back and in the limbs, which may be so marked that the patient shivers violently, while the skin becomes cold, pale, and shrivelled—*cutis anserina*. This is a nervous reaction due to a want of correspondence between the internal and the surface temperature of the body, and is known clinically as a *rigor*. When the temperature rises gradually the chill is usually very slight and may be unobserved. Even during the cold stage, however, the internal temperature is already raised, and by the time the chill has passed off its maximum has been reached.

These disturbances seem to follow the absorption of toxins into the blood, and to be due to an interference with the central heat-regulating mechanism.

The subsequent course of the temperature chart depends on the nature and amount of the poison absorbed: whether it is the pure toxin of a single species of organism, or the result of a mixed infection by more than one species; and whether the supply is intermittent or continuous. It follows, therefore, that certain groups of surgical conditions present particular types of temperature curve resembling one another more or less closely.

In *acute sapræmia*, for instance, where the patient absorbs from a localised focus of infection a definite quantity of toxin either in a single large dose or in repeated small doses, the temperature rises rapidly, remains up till the poison is excreted, or till the source of its production is removed—for example, by amputation—or by the establishment of drainage, after which it falls again and remains normal (Fig. 5).

The temperature may fall very rapidly and become markedly sub-normal (Fig. 5, b).

In the condition known as *hectic*, which is a form of *chronic sapræmia*, the temperature chart is characterised by diurnal variations, ranging from 97° F. in the morning to 102° or 103° F. in the evening. The rise usually begins in the afternoon, and the fall takes place suddenly in the early morning, and is accompanied by profuse sweating (Fig. 6).

The same type of temperature curve is met with in cases of *surgical tuberculosis*, where there is, in all probability, a mixed infection. In these cases the highest temperature may be recorded in the afternoon.

In such conditions as *erysipelas*, where a constant supply of toxins is poured into the system, the temperature remains elevated so long as the disease progresses, but falls more or less rapidly whenever its progress

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is arrested (Fig. 7). A relapse is at once indicated by a second rise of temperature.

In *septicæmia*, organisms as well as toxins enter the circulation,

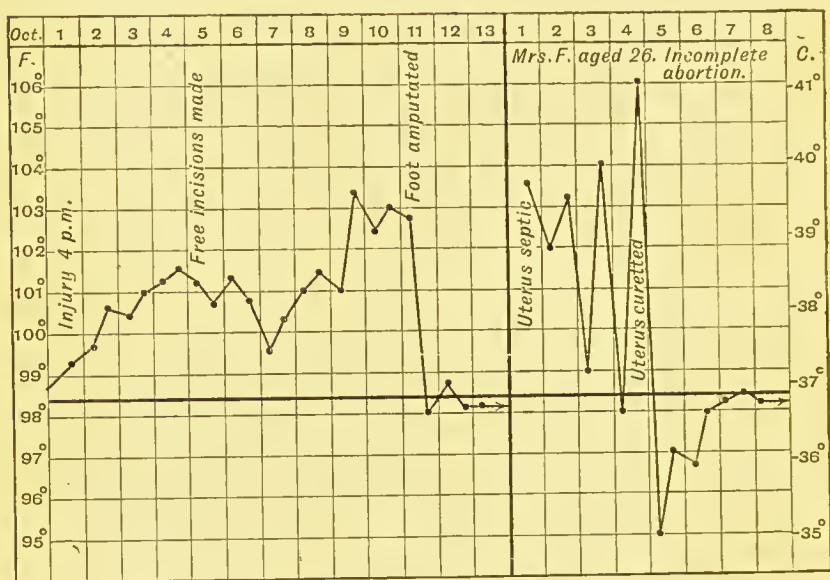


FIG. 5.—Charts of Acute Sapræmia from (a) case of crushed foot, and (b) case of incomplete abortion.

and the temperature charts of this disease vary so widely that it is difficult to determine a type. So long as the disease progresses, the temperature curve is practically the same as that of sapræmia or of

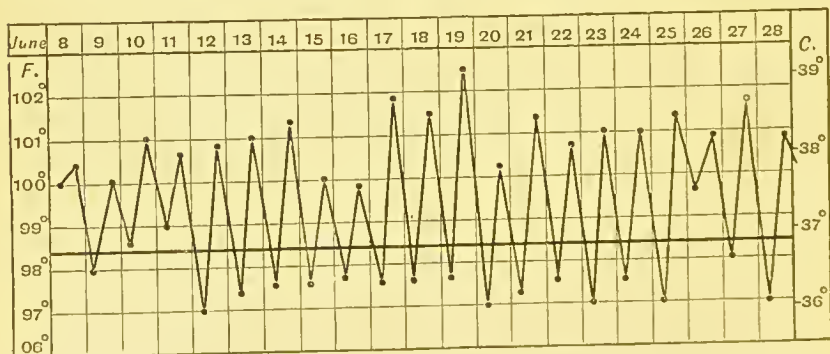


FIG. 6.—Chart of Hectic Fever.

erysipelas ; but after it is arrested, the defervescence is more gradual, the temperature taking several days to reach the normal.

In *pyæmia* secondary abscesses develop in different parts of the body from time to time, forming new foci of toxin production. Each fresh

absorption of poison causes an elevation of temperature, which is usually accompanied by a rigor (Figs. 8, 9).

It is not uncommon for an attack of septicæmia to be followed by pyæmia, and then the type of chart changes (Fig. 10).

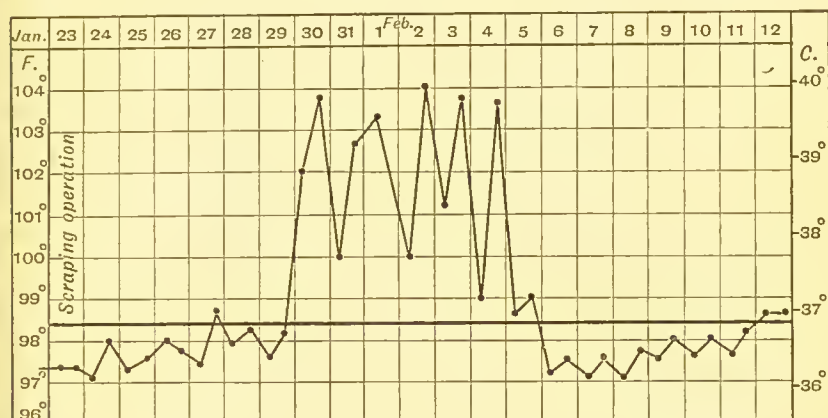


FIG. 7.—Chart of Erysipelas occurring in a wound.

There are certain affections which give rise to chart curves of a definite and distinctive character. Malaria, for example, produces a characteristic alteration of temperature, and patients who have once suffered from this disease are liable to marked rises from comparatively

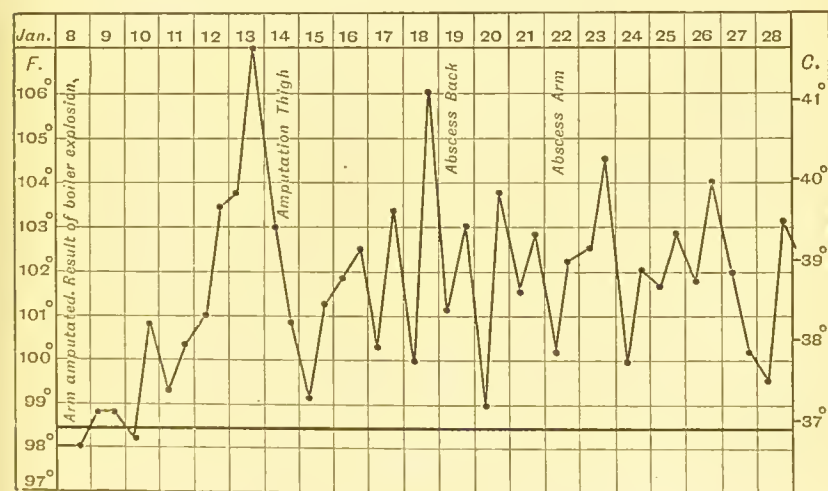


FIG. 8.—Chart of Pyæmia.

trivial causes. After minor operations or slight injuries, for instance, a sudden and marked rise may occur, and cause needless apprehension of septic or other complications. The characteristic curves of other diseases also may be modified by the malarial poison.

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After injuries or operations on the brain or upper part of the spinal cord, sudden and excessive elevation of temperature, unaccompanied by rigors or vascular disturbances of the skin, is not uncommon as a result of direct damage to the central heat-regulating mechanism (Fig. 11).

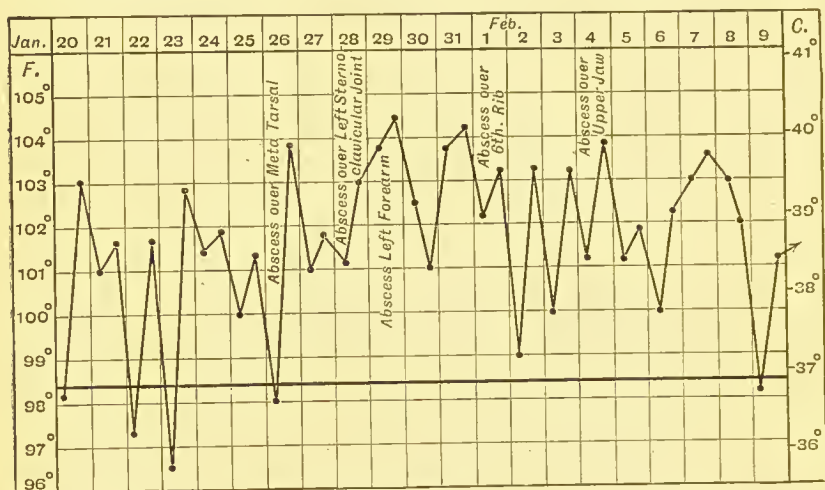


FIG. 9.—Chart of Pyæmia following on Acute Osteomyelitis.

It is almost needless to add that an elevation of temperature in a surgical patient is not always due to his surgical condition. Constipation, influenza, tonsillitis, injurious pressure by splints, the development of a bed-sore, or some other complication, may furnish an explanation.

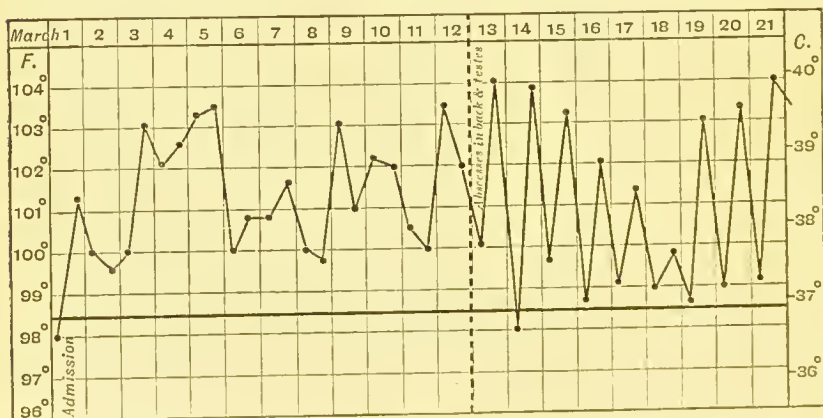


FIG. 10.—Chart of ease of Septicæmia followed by Pyæmia.

Aseptic Fever.—An elevation of temperature, which is unassociated with bacterial infection, is frequently observed after surgical operations which have been attended with considerable shock and loss of blood, as well as after injuries attended with extravasation of blood into the tissues

—for example, fractures. After a slight initial fall, the temperature begins to rise, and in the course of from twelve to sixteen hours reaches 100° or 101° F. It soon declines again, and in from twenty-four to

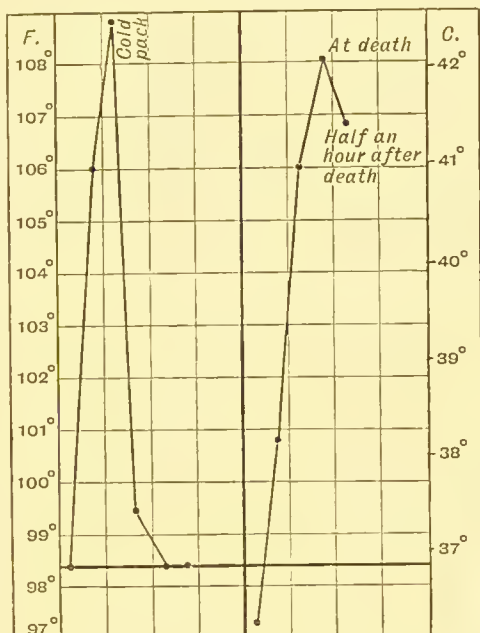


FIG. 11.—Charts of Pyrexia in Head Injuries.

thirty-six hours has regained the normal. This rise is not associated with any of the other signs or symptoms of infection, and has been called *aseptic fever*, being attributed to the absorption into the circulation

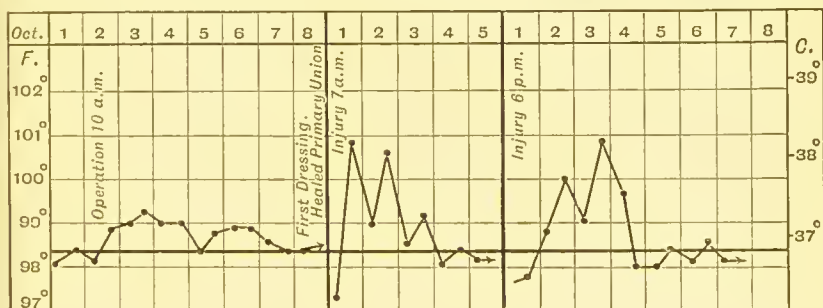


FIG. 12.—Charts of Aseptic Fever.

of certain of the products of disorganised blood or other disintegrated tissue (Fig. 12).

Subnormal Temperature (Algidity).—The general temperature of the body may fall below the normal from various causes. After severe

railway or machinery accidents, for example, or in perforating wounds or diseases of the abdominal viscera, or, again, during the passage of biliary or urinary calculi, profound and dangerous lowering of the temperature may occur. The same result may follow a sudden and copious loss of blood, profuse diarrhoea, or severe vomiting; and it is a characteristic symptom in patients who are slowly starved, as, for example, in cases of stricture of the œsophagus. In most of these conditions, however, if death does not rapidly ensue, the temperature begins to rise and may go beyond the normal.

In some cases of extreme sapræmia or septicæmia also the temperature falls instead of rising, and this indicates a very grave prognosis. In cases of cerebral abscess and in some other conditions causing pressure on the brain, the temperature remains persistently subnormal.

CHAPTER III

METHODS OF WOUND TREATMENT

Varieties of wounds—Modes of infection—Lister's work—Means taken to prevent infection of wounds: *heat; chemical antiseptics; disinfection of hands; preparation of skin of patient; instruments; ligatures; dressings*—Means taken to combat septic infection: *purification; open-wound method.*

THE presence of pyogenic bacteria being the most important factor interfering with the process of repair in wounds, it is necessary that we should now consider the means at our disposal for preventing or counteracting the baneful effects of these organisms.

The surgeon is called upon to treat two distinct classes of wounds: (1) those resulting from injury or disease in which *the skin is already broken*, or in which a communication with a mucous surface exists; and (2) those that he himself makes *through intact skin*, no infected mucous surface being involved.

Infection by bacteria must be assumed to have taken place in all wounds made in any other way than by the knife of the surgeon operating through unbroken skin. On this assumption the modern system of wound treatment is based. Pathogenic bacteria are so widely distributed, that in the ordinary circumstances of everyday life, no matter how trivial a wound may be, or how short a time it may remain exposed, the access of organisms to it is almost certain, unless definite means are employed to prevent this.

It cannot be emphasised too strongly that rigid precautions are to be taken to exclude fresh infection, not only in dealing with wounds which are free of organisms, but equally in the management of wounds and other lesions which are already infected. Any laxity in our methods which admits of fresh organisms reaching an infected wound adds materially to the severity of the septic process and consequently to the patient's risk.

There are many ways in which accidental infection may occur. Take, for example, the case of a person who receives a cut on the face by being knocked down in a carriage accident on the street. Organisms may be introduced to such a wound from the shaft or wheel by which he was struck, from the ground on which he lay, from any portion of his clothing that may have come in contact with the wound, or from his own skin. Or, again, the hands of those who render first aid, the water used to bathe the wound, the handkerchief or other extemporised dressing applied to it, may be the means of conveying bacterial infection. Should the wound open on a mucous surface, such as the mouth or nasal cavity, the organisms constantly present in such situations are liable to prove agents of infection.

Even after the patient has come under professional care the risks of his wound becoming infected are not past, because the hands of the doctor, his instruments, dressings, or other appliances may all, unless carefully purified, become the sources of infection.

In the case of an operation carried out through unbroken skin, organisms may be introduced into the wound from the patient's own skin, from the hands of the surgeon or his assistants, through the medium of contaminated instruments, swabs, ligature or suture materials, or other things used in the course of the operation, or from the dressings applied to the wound.

Further, bacteria may gain access to devitalised tissues by way of the blood-stream, being carried hither from some infected area elsewhere in the body.

The sources of wound infection being so numerous, it is little wonder that in former days few wounds escaped the ravages of pyogenic or other bacteria, and that inflammation, suppuration, erysipelas, hospital gangrene, and pyæmia were of everyday occurrence in surgical practice.

Those who only know the surgical conditions of to-day find it hard to believe that not more than forty years ago, in a leading article in the *Lancet*, the writer stated that at that time "the mortality from compound fractures, amputations, and other operations such as lithotomy is something frightful"; that "death from blood poisoning is not confined to cases of serious operations, but happens ever and anon after operations in themselves trivial. It is lamentable," says the writer, "to think of the extent to which the best and most refined surgery of the time is being frustrated, in our great hospitals, and even

in those most recently built. The risk of blood poisoning is now the one opprobrium of surgery."

To the genius of Lister we owe it that this opprobrium is now removed. In 1867 he began to put into practice the method he had devised for preventing and counteracting the septic process, which he had convinced himself depended upon the action of bacteria. Carbolic acid was the first antiseptic agent he employed, and by its use in compound fractures he soon obtained results such as had never before been attained. The principle was applied to other conditions with like success, and so profoundly has it affected the whole aspect of surgical pathology, that many of the septic diseases with which surgeons formerly had to deal are now all but unknown.

Means taken to prevent Infection of Wounds.—The avenues by which septic agents may gain access to surgical wounds are so numerous and so wide, that it requires the greatest care and the most watchful attention on the part of the surgeon to guard them all. It is only by constant practice and patient attention to technical details, in the operating-room and at the bedside, that the carrying out of surgical manipulations in such a way as to avoid bacterial infection will become an instinctive act and a second nature, and to ensure the best results it is necessary that the efficiency of our methods of sterilisation should be periodically tested. It is only possible here to indicate the chief directions in which danger lies, and to describe the means most generally adopted to avoid it.

To prevent septic infection, it is essential that everything which comes into contact with a wound should be sterilised or disinfected. The two chief agencies at our disposal for this purpose are heat and chemical antiseptics.

Sterilisation by Heat.—The most reliable, and at the same time the most convenient and generally applicable, means of sterilisation is by heat. All bacteria and spores are completely destroyed by being subjected for fifteen minutes to *saturated circulating steam* at a temperature of 130° to 145° C. ($=266^{\circ}$ to 293° F.). The articles to be sterilised are enclosed in a perforated tin casket, which is placed in a specially constructed steriliser, such as that of Schimmelbusch. This apparatus is so arranged that the steam circulates under a pressure of from two to three atmospheres, and permeates everything contained in it. Objects so sterilised are dry when removed from the steriliser. This method is specially suitable for appliances which are not damaged by steam, such, for example, as gauze swabs, towels, aprons, gloves, and metal instruments; it is essential that the

efficiency of the steriliser be tested from time to time by a self-registering thermometer or other means.

The best substitute for circulating steam is *boiling*. The articles are placed in a "fish-kettle steriliser" and boiled for fifteen minutes in a 1 per cent. solution of washing-soda or of lysol.

To prevent contamination of objects that have been sterilised, they must on no account be touched by any one whose hands have not been disinfected and protected by sterilised gloves.

Sterilisation by Chemical Agents.—For the purification of the skin of the patient, the hands of the surgeon, and knives and other instruments that are damaged by heat, recourse must be had to chemical agents. These, however, are less reliable than heat, and are open to certain other objections which will be referred to later.

In selecting a chemical antiseptic the following points should be considered:—(1) The irritant action, toxicity, and absorbability of the antiseptic; (2) the susceptibility to irritation and absorptive power of the surface to which it is to be applied; and (3) its action on surgical instruments.

Carbolic Acid.—This agent is of much historical interest, being that employed by Lister when he first introduced the antiseptic system in 1867. The lotion is made by dissolving the crystals of the pure acid in water in the proportion of 1 in 20, 1 in 40, or 1 in 60. It is a reliable germicide, and has no deleterious action upon metal instruments, but it is irritating to the tissues, and introduces a considerable oozing from raw surfaces. If absorbed, it acts as a general poison, the first sign of its toxic effects being discoloration of the urine, which is olive-green when passed, but changes to black on standing. If absorption goes on, giddiness, nausea, and vomiting are induced. The patient may become profoundly collapsed, with a small, rapid pulse and subnormal temperature, and may ultimately die. Such accidents have occurred from absorption through unbroken skin when a compress of carbolic solution has been applied preparatory to operation, and are most to be feared in children and females with tender skin. The phenol products may be detected in the urine by adding to it a few drops of perchloride of iron solution, which gives a blue colour; or a small quantity of bromine water, which throws down a whitish precipitate of tribromophenol.

Pure carbolic acid (phenol), when applied to a raw surface, does not produce symptoms of poisoning, as it causes coagulation necrosis of the superficial layers of the tissue, and this prevents its being absorbed.

The application of wet compresses of carbolic lotion to the fingers and toes is to be avoided, especially in women and children, on account of the risk of inducing gangrene.

Corrosive Sublimate.—This lotion is made by dissolving the crystals of perchloride of mercury in distilled water. It is used in strengths varying from 1 in 500 to 1 in 5000; that usually employed is 1 in 2000. Although less irritant locally than carbolic lotion, it is more poisonous by absorption, causing abdominal pain, diarrhoea, vomiting,

and collapse, which may prove fatal. It corrodes metal instruments and dishes; and, by its action on the albumen of the tissues and of the blood, forms an inert albuminate of mercury, so that its antiseptic efficiency is diminished or lost. Corrosive sublimate is probably the most efficient lotion for purifying the hands after they have been contaminated with septic material. A 1 in 1000 solution of corrosive sublimate dissolved in 70 per cent. alcohol is one of the most efficient lotions for purifying the hands of the surgeon and the skin of the patient.

Lister's Strong Solution is prepared by making a 1 in 20 solution of carbolic acid in distilled water, in every 500 parts of which one part of perchloride of mercury is dissolved.

Harrington's Solution, which is widely used in the United States, contains one part corrosive sublimate in 1000 parts alcohol containing 6 per cent. hydrochloric acid.

Binioidide of Mercury.—This lotion is widely used as a substitute for corrosive sublimate. It is a more powerful germicide, while it is less irritant, and it neither forms a mercuric albuminate nor tarnishes metal instruments. Binioidide is used in the same strengths as corrosive sublimate, and may be dissolved either in water or in spirit.

Iodine, in the form of the tincture, is one of the most useful antiseptics to apply to infected tissues. Iodine in a 5 per cent. solution in 75 per cent. alcohol is extensively used in preparing the skin of the patient for operation; it acts most efficiently if the skin is previously deprived of moisture and of grease (Grossieh).

Peroxide of Hydrogen (10–15 volumes strength) is of great value in disinfecting and deodorising septic wounds and cavities. It acts in virtue of its oxidising properties. Each volume of the fluid contains from ten to fifteen volumes of oxygen in such feeble combination that it is at once given up when it comes into contact with any oxidisable substance.

Boracic Acid Lotion is a saturated solution of boracic acid crystals in water. It is a weak, non-poisonous lotion of some value as a preventive of sepsis, but of little germicidal power. It is useful in washing out the urinary bladder, as a mouth-wash, and as a bath for burns.

Lysol and *septoform*, among the newer proprietary antiseptics, are useful in cleansing the skin of the patient and the surgeon's hands both before and after operations. They are used in strengths varying from 1 in 100 to 1 in 400, and combine the advantages of an antiseptic solution and a soap. Their irritating action on the skin of the hands may to a large extent be prevented by rinsing the hands in sterile water after washing in the lotion. As they form aropy mixture when brought into contact with pus or blood, they are not suitable lotions for wounds.

Formalin, *izal*, *ereolin*, *antiseptol*, and *sanitas* are useful disinfectant and deodorant lotions.

Iodoform is a feeble germicide, but possesses a peculiar property of neutralising the products of bacteria when it is broken up in contact with the tissues of the body. To this property—probably in virtue of the liberation of free iodine in the process of its disintegration—it owes its undoubted value in wounds with a foul discharge, in tuberculous conditions, and in venereal sores. It is also useful in wounds in the neighbourhood of septic cavities, such as the mouth or rectum, as a means of preventing or controlling sepsis. It is best employed in the form of moderate-sized crystals, which should be sterilised by immersion in 1 in 20 carbolic before being used, as micro-organisms are capable of living in the dried powder.

In children and in weakly old people, symptoms of poisoning by absorption may occur, in the form of loss of appetite, dry tongue, raised temperature and rapid pulse, and mental depression or excitement. These symptoms seem more prone to occur when the drug is used in tissues rich in fat, and especially when the fine powder is employed, this being more readily absorbed than the crystalline form. Iodoform may be detected in the urine of such patients by adding an equal quantity of concentrated hydrochloric acid, and pouring on the surface a little chloride of lime solution. At the junction of the fluids there forms a brown ring, which turns blue on the addition of starch solution.

Some persons show a peculiar idiosyncrasy with regard to their local reaction to iodoform, an acute spreading erythematous or pustular rash, with intense itching, developing from the slightest contact with it. Marked constitutional symptoms may accompany these local manifestations. In some patients persistent vomiting is induced by the smell of the drug.

Aristol, although inferior to iodoform, is preferred by some on account of its less offensive and less persistent odour.

Disinfection of the Hands.—It is now generally recognised that one of the most likely sources of wound infection is the hands of the surgeon and his assistants. It is only by carefully studying to avoid all contact with infective matter that the hands can be kept surgically pure, and that this source of wound infection can be reduced to a minimum. The risk of infection from this source has been greatly reduced by the systematic use of rubber gloves by house-surgeons, dressers, and nurses. The habitual use of gloves has also been adopted by the great majority of surgeons; the minority, who find they are handicapped by wearing gloves as a routine measure, are obliged to do so when operating in septic cases or dressing infected wounds, and in making rectal and vaginal examinations.

The gloves may be sterilised by steam, and are then put on dry, or by boiling, in which case they are put on wet. The gauntlet of the glove should overlap and confine the end of the sleeve of the sterilised overall, and the gloved hands are rinsed in lotion before and at frequent intervals during the operation. The hands are sterilised before putting on the gloves, preferably by a method which dehydrates the skin. Cotton gloves may be worn by the surgeon when tying ligatures, or between operations, and by the anaesthetist during operations on the head, neck, and chest.

The first step in the disinfection of the hands is the mechanical removal of gross surface dirt and loose epithelium by soap, a stream of running water, and a loafal or nail-brush. The nails should be cut down till there is no sulcus between the nail edge and the pulp of the finger in which organisms may lodge. The hands are then washed in running water as

hot as can be borne, and scrubbed with a loofah or a nail-brush that has been previously sterilised by heat. They are next washed for three minutes in methylated spirit to dehydrate the skin, and then for two or three minutes in 70 per cent. sublimate or biniodide alcohol (1 in 1000). Finally, the hands are rubbed with dry sterilised gauze.

Preparation of the Skin of the Patient.—In the purification of the skin of the patient before operation, reliance is to be placed chiefly in the mechanical removal of dirt and grease by the same means as are taken for the cleansing of the surgeon's hands. Hair-covered parts should be shaved. The skin is then dehydrated by washing with methylated spirit, followed by 70 per cent. sublimate or biniodide alcohol (1 in 1000). This is done some hours before the operation, and the part is then covered with pads of dry sterilised gauze or a sterilised towel. Immediately before the operation the skin is again purified in the same way.

The *iodine method* of disinfecting the skin introduced by Grossich is simple, and apparently equally efficient. The day before operation the skin, after being washed with soap and water, is shaved, is dehydrated by means of methylated spirit, and is then painted with a 5 per cent. solution of iodine in rectified spirit. The painting with iodine is repeated just before the operation commences, and again after it is completed. The final application is omitted in the case of children. In emergency operations the skin is shaved dry and dehydrated with spirit, after which the iodine is applied as described above.

If any acne pustules or septic sinuses are present, they should be destroyed or purified by means of the thermo-cautery or pure carbolic acid, after the patient is anaesthetised.

Instruments that are not damaged by heat must be boiled in a fish-kettle or other suitable steriliser for fifteen minutes in a 1 per cent. solution of lysol or caustic soda. Just before the operation begins they are removed in the tray of the steriliser and placed on a sterilised towel within reach of the surgeon or his assistant. Knives and instruments that are liable to be damaged by heat should be purified by being soaked in pure lysol for a few minutes, or in 1 in 20 carbolic for at least an hour.

Pads of Gauze sterilised by compressed circulating steam have almost entirely superseded marine sponges for operative purposes. To avoid the risk of leaving swabs in the peritoneal cavity, large square pads of gauze, to one corner of which a piece of strong tape about a foot long is securely stitched,

should be employed (Mikulicz). They should be removed from the caskets in which they are sterilised by means of sterilised forceps, and handed direct to the surgeon. The assistant who attends to the swabs should wear sterilised gloves.

Ligatures and sutures.—To avoid the risk of implanting infective matter in a wound by means of the materials used for ligatures and sutures, great care must be taken in their preparation.

Catgut.—The following methods of preparing catgut have proved satisfactory:—(1) The gut is soaked in juniper oil for at least a month; the juniper oil is then removed by ether and alcohol, and the gut preserved in 1 in 1000 solution of corrosive sublimate in alcohol (Kocher). (2) The gut is placed in a brass receiver and boiled for three-quarters of an hour in a solution consisting of 85 per cent. absolute alcohol, 10 per cent. water, and 5 per cent. carbolic acid, and is then stored in 90 per cent. alcohol. (3) Cladius recommends that the catgut, just as it is bought from the dealers, be loosely rolled on a spool, and then immersed in a solution of—iodine, 1 part; iodide of potassium, 1 part; distilled water, 100 parts. At the end of eight days it is ready for use. Moschcowitz has found that the tensile strength of catgut so prepared is increased if it is kept dry in a sterile vessel, instead of being left indefinitely in the iodine solution. If Salkindsohn's formula is used—tincture of iodine, 1 part; proof spirit, 15 parts—the gut can be kept permanently in the solution without becoming brittle. To avoid contamination from the hands, catgut should be removed from the bottle with aseptic forceps and passed direct to the surgeon. Any portion unused should be thrown away.

Silk is prepared by being soaked for twelve hours in ether, for other twelve in alcohol, and then boiled for ten minutes in 1 in 1000 sublimate solution. It is then wound on spools with purified hands protected by sterilised gloves, and kept in absolute alcohol. Before an operation the silk is again boiled for ten minutes in the same solution, and is used directly from this (Kocher). Linen thread is sterilised in the same way as silk.

Fishing-gut and silver wire, as well as the needles, should be boiled along with the instruments. Horse-hair and fishing-gut may be sterilised by prolonged immersion in 1 in 20 carbolic, or in the iodine solutions employed to sterilise catgut.

The field of operation is surrounded by sterilised towels, clipped to the edges of the wound, and securely fixed in position so that no contamination may take place from the surroundings.

The surgeon and his assistants, including the anæsthetist, wear overalls sterilised by steam. To avoid the risk of infection from dust, scurf, or drops of perspiration falling from the head, the surgeon and his assistants may wear sterilised cotton caps. It has been shown that there is a risk of infection taking place by drops of saliva projected from the mouth in talking or coughing in the vicinity of a wound. To obviate this risk a simple mask may be worn.

The risk of infection from the *air* is now known to be very small, so long as there is no excess of dust floating in it. All sweeping, dusting, and disturbing of curtains, blinds, or furniture must therefore be avoided before or during an operation.

It has been shown that the presence of spectators increases the number of organisms in the atmosphere. In teaching clinics, therefore, the risk from air infection is greater than in private practice.

To facilitate primary union, all hæmorrhage should be arrested, and the accumulation of fluid in the wound prevented. When much oozing is anticipated a glass or rubber drainage-tube is inserted through a small opening specially made for the purpose. In aseptic wounds the tube may be removed in from twenty-four to forty-eight hours, and where it is important to avoid a scar, the opening should be closed with a Michel's clip; in infected wounds the tube must remain as long as the discharge continues.

The fascia and skin should be brought into accurate apposition by sutures. If any cavity exists in the deeper part of the wound, it should be obliterated by buried sutures, or by so adjusting the dressing as to bring its walls into apposition.

If our precautions have been successful, the wound will heal under the original dressing, which need not be interfered with for from ten to fourteen days, according to the nature of the case.

Dressings.—*Gauze*, either sterilised by heat, or impregnated with corrosive sublimate, double cyanide of mercury and zinc, iodoform, or other antiseptic agent, is widely used as a dressing for wounds. *Double cyanide gauze* is to be preferred in such regions as the neck, axilla, or groin, where complete

sterilisation of the skin is difficult to attain, and where it is desirable to leave the dressing undisturbed for ten days or more. *Iodoform gauze* is of special value for the packing of wounds treated by the open method.

One variety or another of *wool*, rendered absorbent by the extraction of its fat, and sterilised by heat, forms a part of almost every surgical dressing, and various antiseptic agents may be added to it. Of these, corrosive sublimate is the most generally used. Wood-wool dressings are more highly and more uniformly absorbent than cotton wools. As evaporation takes place through wool dressings, the discharge becomes dried, and so forms an unfavourable medium for bacterial growth.

Boracic Lint is prepared by soaking ordinary lint in a hot concentrated solution of boracic acid and then drying it. It is usually employed as a wet dressing or poultice, being wrung out of boracic lotion, applied to the part, and covered with gutta-percha tissue.

Means adopted to combat Septic Infection.—As has already been indicated, the same antiseptic precautions are to be taken in dealing with infected as with aseptic wounds.

In the case of *recent injuries* such as result from railway or machinery accidents, with bruising and crushing of the tissues and grinding of gross dirt into the wounds, the scissors must be freely used to remove the tissues that have been devitalised or impregnated with foreign material. Hair-covered parts should be shaved and the surrounding skin painted with iodine. Crushed and contaminated portions of bone should be chiselled away. Opinions differ as to the benefit derived from washing such wounds with chemical antiseptics, which are liable to devitalise the tissues with which they come in contact, and so render them less able to resist the action of any organisms that may remain in them. All are agreed, however, that free washing with normal salt solution is useful in mechanically cleansing the injured parts. Peroxide of hydrogen sprayed over such wounds is also beneficial in virtue of its oxidising properties. Efficient drainage must be provided, and stitches should be used sparingly, if at all.

The best way in which to treat such wounds is by the *open method*. This consists in packing the wound with iodoform gauze, which is left in position as long as it adheres to the raw surface. The packing may be renewed at intervals until the wound is filled by granulations; or, in the course of a few days, when it becomes evident that the septic infection has

been overcome, *secondary* sutures may be introduced and the edges drawn together, provision being made at the ends for further packing or for drainage-tubes.

If earth or street dirt has entered the wound, the surface may with advantage be brushed over with pure carbolic acid, as virulent organisms, such as those of tetanus or spreading gangrene, are liable to be present.

CHAPTER IV

INFLAMMATION

Definition—Nature of inflammation from surgical point of view—
Sequence of changes in bacterial inflammation—Clinical aspects
of inflammation—General principles of treatment—Chronic inflammation.

INFLAMMATION may be defined as the series of vital changes that occur in the tissues in response to irritation. These changes represent the reaction of the tissue elements to the irritant, and constitute the attempt made by nature to arrest or to limit its injurious effects, and to repair the damage done by it.

The phenomena which characterise the inflammatory reaction can be induced by any form of irritation—such, for example, as mechanical injury, the application of heat or of chemical substances, or the action of pathogenic bacteria and their toxins, and they are essentially similar in kind whatever the irritant may be. The extent to which the process may go, however, and its effects on the part implicated and on the system as a whole, vary with different irritants and with the intensity and duration of their action. A mechanical, a thermal, or a chemical irritant, acting alone, induces a degree of reaction directly proportionate to its physical properties, and so long as it does not completely destroy the vitality of the part involved, the changes in the tissues are chiefly directed towards repairing the damage done to the part, and the inflammatory reaction is not only compatible with the occurrence of ideal repair, but may be looked upon as an integral step in the reparative process.

The irritation caused by infection with bacteria, on the other hand, is cumulative, as the organisms not only multiply in the tissues, but in addition produce chemical poisons (toxins) which aggravate the irritative effects. The resulting reaction is correspondingly progressive, and has as its primary object the

expulsion of the irritant and the limitation of its action. If the natural protective effort is successful, the resulting tissue changes subserve the process of repair, but if the bacteria gain the upper hand in the struggle, the inflammatory reaction becomes more intense, certain of the tissue elements succumb, and the process for the time being is a destructive one. During the stage of bacterial inflammation, reparative processes are in abeyance, and it is only after the inflammation has been allayed, either by natural means or by the aid of the surgeon, that repair takes place.

In applying the antiseptic principle to the treatment of surgical wounds, our main object is to exclude or to eliminate the bacterial factor, and so to prevent the inflammatory reaction going beyond the stage in which it is protective, and just in proportion as we succeed in attaining this object do we favour the occurrence of ideal repair.

Sequence of Changes in Bacterial Inflammation.—As the form of inflammation with which we are most concerned is that due to the action of bacteria, in describing the process by which the protective influence of the inflammatory reaction is brought into play, we shall assume the presence of a bacterial irritant.

The introduction into the tissues of a colony of micro-organisms is quickly followed by an accumulation of wandering cells, and a proliferation of connective tissue cells in the vicinity of the injury. The various cells are attracted to the bacteria by a peculiar chemical or biological power known as *chemiotaxis*, which is believed to depend upon some substance produced by the micro-organisms. Changes in the blood-vessels then ensue, the arteries becoming dilated and the rate of the current in them being for a time increased—*active hyperæmia*. Soon, however, the rate of the blood flow becomes slower than normal, and in course of time the current may cease—*stasis*, and the blood in the vessels may even coagulate—*thrombosis*. Coincidentally with these changes in the vessels, the leucocytes in the blood of the inflamed part rapidly increase in number, and they become viscous and adhere to the vessel wall, where they may accumulate in large numbers. In course of time the leucocytes pass through the vessel wall—*emigration of leucocytes*—and move towards the seat of infection, giving rise to a marked degree of *local leucocytosis*. Through the openings by which the leucocytes have escaped from the vessels, red corpuscles may be passively extruded—*diapedesis of red corpuscles*. These processes are accompanied by changes in the endothelium of the vessel walls, which result in an increased formation of

lymph, which escapes into the meshes of the connective tissue, giving rise to an *inflammatory œdema*, or, if the inflammation is on a free surface, forming an *inflammatory exudate*.

The quantity and characters of this exudate vary in different parts of the body, and according to the organisms causing the inflammation. Thus it may be *serous*, as in some forms of synovitis; *sero-fibrinous*, as in certain varieties of peritonitis, the fibrin tending to limit the spread of the inflammation by forming adhesions; *croupous*, when it coagulates on a free surface and forms a false membrane, as in diphtheria; *hæmorrhagic*, when mixed with blood; or *purulent*, when suppuration has occurred. Certain varieties of leucocytes, probably the eosinophile cells, seem to have the power of producing bactericidal substances—*opsonins* or *alexines*, which act on the bacteria in such a way as to render them an easy prey to the phagocytes. These phagocytic cells—polymorph leucocytes, proliferating connective tissue and endothelial cells—move towards the bacteria thus prepared for them, and by ingesting them render them inert or destroy them by a process of intra-cellular digestion.

By these various processes, then, the protective influence of the inflammatory reaction is exerted, and, if the attempt to repel the invading organisms is successful, the irritant effects are overcome, the inflammation is arrested, and *resolution* is said to take place. Certain of the vascular and cellular changes are now utilised to restore the condition to the normal, and *repair* ensues after the manner already described (p. 2).

In certain situations, notably in tendon sheaths, in the cavities of joints, and in the interior of serous cavities, for example the pleura and peritoneum, the restoration to the normal is not perfect, adhesions forming between the opposing surfaces.

If, however, the reaction induced by the infection is insufficient to check the growth and spread of the organisms, or to inhibit their toxin production, local necrosis of tissue may take place, either in the form of suppuration or of gangrene, or the toxins absorbed into the circulation may produce blood-poisoning, which may even prove fatal.

Clinical Aspects of Inflammation.—It must clearly be understood that inflammation is not to be looked upon as a disease in itself, but rather as an evidence of some infective process going on in the tissues in which it occurs, and of an effort on the part of these tissues to overcome the invading organisms and their products. The chief danger to the patient lies, not

in the reactive changes that constitute the inflammatory process, but in the fact that he is liable to be poisoned by the toxins of the bacteria at work in the inflamed area.

Since the days of Celsus (first century, A.D.), heat, redness, swelling, and pain have been recognised as cardinal signs of inflammation, and to these may be added, interference with function in the inflamed part, and generally constitutional disturbance. Variations in these signs and symptoms depend upon the acuteness of the condition, the nature of the causative organism and of the tissue attacked, the situation of the part in relation to the surface, and other factors.

The *heat* of the inflamed part is to be attributed to the increased quantity of blood present in it, and the more superficial the affected area the more readily is the local increase of temperature detected by the hand. This clinical point is best tested by placing the palm of the hand and fingers for a few seconds alternately over an uninflamed and an inflamed area, otherwise under similar conditions as to coverings and exposure. In this way even slight differences may be recognised.

Redness, similarly, is due to the increased afflux of blood to the inflamed part. The shade of colour varies with the stage of the inflammation, being lighter and brighter in the early, hyperæmic stages, and darker and dusker when the blood flow is slowed or when stasis has occurred and the oxygenation of the blood is defective. In the thrombotic stage the part may assume a purplish hue.

The *swelling* is partly due to the increased amount of blood in the affected part and to the accumulation of leucocytes and proliferated tissue cells, but chiefly to the exudate in the connective tissue—*inflammatory œdema*. The more open the structure of the tissue of the part, the greater is the amount of swelling—witness the marked degree of œdema that occurs in such parts as the scrotum or the eyelids.

Pain is a symptom seldom absent in inflammation. *Tenderness*—that is, pain elicited on pressure—is one of the most valuable diagnostic signs we possess, and is often present before pain is experienced by the patient. That the area of tenderness corresponds to the area of inflammation is almost an axiom of surgery. Pain and tenderness are due to the irritation of nerve filaments of the part, rendered all the more sensitive by the abnormal conditions of their blood-supply. In inflammatory conditions of internal organs, for example the abdominal viscera, the pain is frequently referred to other

parts, usually to an area supplied by branches of the same nerve as that supplying the inflamed part.

For purposes of diagnosis, attention should be paid to the terms in which the patient describes his pain. For example, the pain caused by an inflammation of the skin is usually described as of a *burning* or *itching* character; that of inflammation in dense tissues like periosteum or bone, or in encapsuled organs, as *dull*, *boring*, or *aching*. When inflammation is passing on to suppuration the pain assumes a *throbbing* character, and as the pus reaches the surface, or "points," as it is called, sharp, *darting*, or *lancinating* pains are experienced. Inflammation involving a nerve-trunk may cause a *boring* or a *tingling* pain; while the implication of a serous membrane such as the pleura or peritoneum gives rise to a pain of a sharp, *stabbing* character.

Interference with the function of the inflamed part is always present to a greater or less extent.

Constitutional Disturbances.—Under the term constitutional disturbances are included the presence of fever or elevation of temperature; certain changes in the pulse rate and the respiration; gastro-intestinal and urinary disturbances; and derangements of the central nervous system. These are all due to the absorption of toxins into the general circulation. The nature and significance of alterations in the temperature in inflammatory conditions have already been referred to (p. 24). The *pulse* is always increased in frequency, and usually varies directly with the height of the temperature. *Respiration* is more active during the progress of an inflammation; and bronchial catarrh is common, apart from any antecedent local respiratory disease.

Gastro-intestinal disturbances are usually present in the form of loss of appetite, vomiting, diminished secretion of alimentary juices, and weakening of the peristalsis of the bowel, leading to thirst, dry, furred tongue, and constipation. Diarrhoea is sometimes present. The *urine* is usually scanty, of high specific gravity, rich in nitrogenous substances, especially urea and uric acid, and in calcium salts, while sodium chloride is deficient. Albumin and hyaline casts may be present in cases of severe inflammation with high temperature. The significance of general *leucocytosis* has already been referred to (p. 22).

General Principles of Treatment.—The capacity of the inflammatory reaction for dealing with bacterial infections being limited, it often becomes necessary for the surgeon to aid the natural defensive processes, as well as to counteract

the local and general effects of the reaction, and to relieve symptoms.

The ideal means of helping the tissues is by removing the focus of infection, and when this can be done, as for example in a carbuncle or an anthrax pustule, the infected area may be completely excised. When the focus is not sufficiently limited to admit of this, the infected tissue may be scraped away with the sharp spoon, or destroyed by caustics or by the actual cautery. If this is inadvisable, the organs may be attacked by strong antiseptics, such as pure carbolic acid.

Moist antiseptic dressings favour the removal of bacteria by promoting the escape of the inflammatory exudate, in which they are washed out.

Artificial hyperæmia.—When such direct means as the above are impracticable, much can be done to aid the tissues in their struggle by improving the condition of the circulation in the inflamed area, so as to ensure that a plentiful supply of fresh arterial blood reaches it. The beneficial effects of *hot fomentations and poultices* depend on their causing a dilatation of the vessels, and so inducing a hyperæmia in the affected area. It is now believed that the so-called *counter-irritants*—mustard, iodine, cantharides, actual cautery—act in the same way; and the method of treating erysipelas by applying a strong solution of iodine around the affected area (p. 119) is based on the same principle.

While these and similar methods have long been employed in the treatment of inflammatory conditions, it is only within recent years that their mode of action has been properly understood, and to August Bier belongs the credit of having put the treatment of inflammation on a scientific and rational basis. Recognising the “beneficent intention” of the inflammatory reaction, and the protective action of the leucocytosis which accompanies the hyperæmic stages of the process, Bier was led to study the effects of increasing the hyperæmia by artificial means. As a result of his observations, he has formulated a method of treatment which consists in inducing an artificial hyperæmia in the inflamed area, either by obstructing the venous return from the part (*passive hyperæmia*), or by stimulating the arterial flow through it (*active hyperæmia*).

Bier's Constricting Bandage.—To induce a *passive hyperæmia* in a limb, an elastic bandage is applied some distance above the inflamed area sufficiently tightly to obstruct the venous return from the distal parts without arresting in any way the inflow of arterial blood. If the constricting band is correctly applied,

the parts beyond become swollen and œdematous, and assume a bluish-red hue, but they retain their normal temperature, the pulse is unchanged, and there is no pain. If the part becomes blue, cold, or painful, or if any existing pain is increased, the band has been applied too tightly. The hyperæmia is kept up from twenty to twenty-two hours out of the twenty-four, and in the intervals the limb is elevated to get rid of the œdema and to empty it of impure blood, and so make room for a fresh supply of healthy blood when the bandage is re-applied. As the inflammation subsides, the period during which the



FIG. 13.—Passive Hyperæmia of Hand and Forearm induced by Bier's Bandage.

band is kept on each day is diminished; but the treatment should be continued for some days after all signs of inflammation have subsided.

This method of treating acute inflammatory conditions necessitates close supervision on the part of the surgeon until the correct degree of tightness of the band has been determined.

Klapp's Suction Bells.—In inflammatory conditions to which the constricting band cannot be applied, as for example an acute mastitis, a bubo in the groin, or a boil on the neck, the affected area may be rendered hyperæmic by an appropriately

shaped glass bell applied over it and exhausted by means of a suction pump, the rarefaction of the air in the bell determining a flow of blood into the tissues enclosed within it. The edge of the bell is smeared with vaseline, and the suction applied for from five to ten minutes at a time, with a corresponding interval between the applications. Each sitting lasts for from half an hour to an hour, and the treatment may be carried out once or twice a day according to circumstances. This apparatus, which acts in the same way as the old-fashioned *dry cup*, is more convenient and equally efficacious.

Active hyperæmia is induced by the local application of



FIG. 14.—Passive Hyperæmia of Finger induced by Klapp's Suction Bell.

heat, particularly by means of hot air. It has not proved so useful in acute inflammation as passive hyperæmia, but is of great value in hastening the absorption of inflammatory products and in overcoming adhesions and stiffness in tendons and joints.

General Treatment.—The patient should be kept at rest, preferably in bed, to diminish the general tissue waste; and the diet should be restricted to fluids, such as milk, beef-tea, meat juices or gruel, and these may be rendered more easily assimilable by artificial digestion if necessary. To counteract the general effect of toxins absorbed into the circulation, specific antitoxic sera are employed in certain forms of infection, such

as diphtheria, streptococcal septicæmia, and tetanus. In other forms of infection, vaccines are employed to increase the opsonic power of the blood (p. 15). When such means are not available, the circulating toxins may to some extent be diluted by giving plenty of bland fluids by the mouth or normal salt solution by the rectum.

The elimination of the toxins is promoted by securing free action of the emunctories. A saline purge, such as half an ounce of sulphate of magnesium in a small quantity of water, ensures a free evacuation of the bowels. The kidneys are flushed by such diluent drinks as equal parts of milk and lime water, or milk with a dram of liquor calcis saccharatus added to each tumblerful. Barley-water and "Imperial drink," which



FIG. 15.—Passive Hyperæmia induced by Klapp's Suction Bell for Inflammation of Inguinal Gland.

consists of a dram and a half of cream of tartar added to a pint of boiling water and sweetened with sugar after cooling, are also useful and non-irritating diuretics. The skin may be stimulated by Dover's powder (10 grains) or liquor ammoniæ acetatis in three-dram doses every four hours.

Various drugs administered internally, such as quinine, salol, salicylate of iron, and others, have a reputation, more or less deserved, as internal antiseptics.

Weakness of the heart, as indicated by the condition of the pulse, is treated by the use of such drugs as digitalis, strophanthus, or strychnin, according to circumstances.

Gastro-intestinal disturbances are met by ordinary medical means. Vomiting, for example, can sometimes be checked by effervescing drinks, such as citrate of caffeine, or by dilute

hydrocyanic acid and bismuth. In severe cases, and especially when the vomited matter resembles coffee-grounds from admixture with altered blood—the so-called post-operative hæmatemesis—the best means of arresting the vomiting is by washing out the stomach. Thirst is relieved by rectal injections of saline solution. The introduction of saline solution into the veins or by the rectum is also useful in diluting and hastening the elimination of circulating toxins.

In surgical inflammations, as a rule, nothing is gained by lowering the temperature, unless at the same time the cause is removed. When severe or prolonged pyrexia becomes a source of danger, the use of hot or cold sponging, or even the cold bath, is preferable to the administration of drugs internally.

Relief of Symptoms.—For the relief of *pain*, rest is essential. The inflamed part should be placed in a splint or other appliance which will prevent movement, and steps must be taken to reduce its functional activity as far as possible. Locally, warm and moist dressings, such as an antiseptic poultice or fomentation, may be used. To make a fomentation, a piece of flannel or lint is wrung out of very hot water or antiseptic lotion and applied under a sheet of mackintosh. Fomentations should be renewed as often as they cool. An ordinary india-rubber bag filled with hot water and fixed over the fomentation, by retaining the heat, obviates the necessity of frequently changing the application. The addition of a few drops of laudanum sprinkled on the flannel has a soothing effect. Lead and opium lotion is a useful, soothing application employed as a fomentation. Belladonna and glycerine, equal parts; ichthyol ointment (1 in 3), or a 10 per cent. aqueous or glycerine solution of ichthyol, may be used.

Dry cold obtained by means of icebags, or by Leiter's lead tubes through which a continuous stream of ice-cold water is kept flowing, is sometimes soothing to the patient, but when the vessels in the inflamed part are greatly congested, its use is attended with considerable risk, as it not only contracts the arterioles supplying the part, but also diminishes the outflow of venous blood, and so may determine gangrene of tissues already devitalised.

A milder form of employing cold is by means of evaporating lotions: a thin piece of lint or gauze is applied over the inflamed part and kept constantly moist with the lotion, the dressing being left freely exposed to allow of continuous evaporation. A useful evaporating lotion is made up as

follows: take of chloride of ammonium, half an ounce; rectified spirit, one ounce; and water, seven ounces.

The administration of opiates may be necessary for the relief of pain.

The accumulation of an excessive amount of inflammatory exudate may endanger the vitality of the tissues by pressing on the blood-vessels to such an extent as to cause stasis, and by concentrating the local action of the toxins. Under such conditions the tension should be relieved and the exudate with its contained toxins removed by making an incision into the inflamed tissues, and then applying a suction bell. When the exudate has collected in a synovial cavity, such as a joint or bursa, it may be withdrawn by means of a trocar and cannula. There are other methods of withdrawing blood and exudates from an inflamed area, for example by leeches or wet-cupping, but they are seldom employed now. Before applying leeches the part must be thoroughly cleansed, and if the leech is slow to bite, may be smeared with cream. The leech is retained in position under an inverted wine-glass or wide test-tube till it takes hold. After it has sucked its fill it usually drops off, having withdrawn a dram or a dram and a half of blood. If it be desirable to withdraw more blood, hot fomentations should be applied to the bite. As it is sometimes necessary to employ considerable pressure to stop the bleeding, leeches should, if possible, be applied over a bone which will furnish the necessary resistance. The use of styptics may be called for.

Wet-cupping has almost entirely been superseded by the use of Klapp's suction bells.

General blood-letting consists in opening a superficial vein (venesection) and allowing from eight to ten ounces of blood to flow from it. It is seldom used in the treatment of surgical forms of inflammation.

Counter-irritants.—In deep-seated inflammations, counter-irritants are sometimes employed in the form of mustard leaves or blisters, according to the degree of irritation required. A mustard leaf or plaster should not be left on longer than ten or fifteen minutes, unless it is desired to produce a blister. Blistering may be produced by a *cantharides plaster*, or by painting with *liquor epispasticus*. The plaster should be left on from eight to ten hours, and if it has failed to raise a blister, a hot fomentation should be applied to the part. *Liquor epispasticus*, alone or mixed with equal parts of collodion, is painted on the part with a brush. Several

paintings are often required before a blister is raised. The removal of the natural grease from the skin by ether favours the action of these applications.

The treatment of inflammation in special tissues and organs will be considered in the sections devoted to regional surgery.

Chronic Inflammation.—Chronic inflammatory processes are almost invariably due to the action of the specific virus of such affections as tubercle, syphilis, actinomycosis, or other infective disease, and will be described in the sections dealing with these conditions.

CHAPTER V

SUPPURATION

Definition—Pus—*Varieties*—Acute circumscribed abscess—*Acute suppuration in a wound—Acute suppuration in a mucous membrane—*Diffuse cellulitis and diffuse suppuration—*Whillow—Suppurative cellulitis in different situations—*Chronic suppuration—Sinus, Fistula—Constitutional manifestations of pyogenic infection—*Supremia—Septicemia—Pyemia.*

SUPPURATION, or the formation of pus, is one of the results of the action of bacteria on the tissues of the body. The invading organism is usually one of the staphylococci, less frequently a streptococcus, and still less frequently one of the other bacteria capable of producing pus, such as the bacillus coli communis, the gonococcus, the pneumococcus, or the typhoid bacillus.

So long as the tissues are in a healthy condition they are able to withstand the attacks of moderate numbers of pyogenic bacteria of ordinary virulence, but when devitalised by disease, by injury, or by inflammation due to the action of other pathogenic organisms, suppuration ensues.

Pus.—The fluid resulting from the process of suppuration is known as *pus*. In its typical form it is a yellowish creamy substance, of alkaline reaction, with a specific gravity of about 1030, and it has a peculiar mawkish odour. If allowed to stand in a test-tube it does not coagulate, but separates into two layers: the upper, transparent, straw-coloured fluid, the *liquor puris* or pus serum, closely resembling blood serum in its composition, but containing less proteid and more cholesterin; it also contains leucin, tryosin, and certain albumoses which prevent coagulation.

The layer at the bottom of the tube consists for the most part of polymorph leucocytes, and proliferated connective tissue and endothelial cells (*pus corpuscles*). Other forms of leucocytes may be present, especially in long-standing

suppurations; and there are usually some red corpuscles, dead bacteria, fat cells and shreds of tissue, cholesterin crystals, and other detritus in the deposit.

If a film of fresh pus is examined under the microscope, the pus cells are seen to have a well-defined rounded outline, and to contain a finely granular protoplasm and a multi-partite nucleus; if still warm, the cells may exhibit amœboid movement. In stained films the nuclei take the stain well. In older pus cells the outline is irregular, the protoplasm coarsely granular, and the nuclei disintegrated, no longer taking the stain.

Variations from Typical Pus.—Pus from old-standing sinuses is often watery in consistence (ichorous), with few cells. Where the granulations are vascular and bleed easily, it becomes sanious from admixture with red corpuscles; while, if a blood-clot be broken down and the debris mixed with the pus, it contains granules of blood pigment and is said to be “grumous.” The *odour* of pus varies with the different bacteria producing it. Pus due to ordinary pyogenic cocci has a mawkish odour; when putrefactive organisms are present it has a putrid odour; when it forms in the vicinity of the intestinal canal it usually contains the bacillus coli communis, and has a fæcal odour.

The *colour* of pus also varies: when due to one or other of the varieties of the bacillus pyocyaneus, it is usually of a blue or green colour; when mixed with bile derivatives or altered blood pigment, it may be of a bright orange colour. In wounds inflicted with rough iron implements from which rust is deposited, the pus often presents this same colour.

The pus may form and collect within a circumscribed area, constituting a localised *abscess*; or it may infiltrate the tissues over a wide area—*diffuse suppuration*.

ACUTE CIRCUMSCRIBED ABSCESS

Any tissue of the body may be the seat of an acute abscess, and there are many routes by which the bacteria may gain access to the affected area. For example: an abscess in the integument or subcutaneous cellular tissue usually results from infection by organisms which have entered through a wound or abrasion of the surface, or along the ducts of the skin; an abscess in the breast from organisms which have passed along the milk ducts opening on the nipple, or along the lymphatics which accompany these. An abscess in lymphatic

glands is usually due to infection passing by way of the lymphatic channels from the area of skin or mucous membrane drained by them. Abscesses in internal organs, such as the kidney, liver, or brain, usually result from organisms carried in the blood-stream from some focus of infection elsewhere in the body.

Formation of an Abscess.—When pyogenic bacteria are introduced into the tissues there ensues an inflammatory reaction, which is characterised by dilatation of the blood-vessels, exudation of serum, migration of large numbers of leucocytes, and proliferation of connective-tissue cells. These wandering cells soon accumulate around the focus of infection, and form a protective barrier which tends to prevent the spread of the organisms and to restrict their field of action. Within the area thus circumscribed the struggle between the bacteria and the phagocytes takes place, and in the process toxins are formed by the organisms, a certain number of the leucocytes succumb, and, becoming disintegrated, set free certain proteolytic enzymes or ferments. The toxins cause coagulation-necrosis of the tissue cells with which they come in contact, the ferments liquefy the exudate and other albuminous substances, and in this way *pus* is formed.

If the bacteria gain the upper hand, this process of liquefaction, which is characteristic of suppuration, extends into the surrounding tissues, the protective barrier of leucocytes is broken down, and the suppurative process spreads. A fresh accession of leucocytes, however, forms a new barrier, and eventually the spread is arrested, and the collection of pus so hemmed in constitutes an *abscess*.

Owing to the swelling and condensation of the parts around, the pus thus formed is under considerable pressure, and this causes it to burrow along the lines of least resistance. In the case of a subcutaneous abscess the pus usually works its way towards the surface, and “points,” as it is called. Where it approaches the surface the skin becomes soft and thin, and eventually gives way, allowing the pus to escape.

An abscess forming in the deeper planes is prevented from pointing directly to the surface by the firm fasciæ and other fibrous structures. The pus therefore tends to burrow along the line of the blood-vessels and in the connective-tissue septa, till it either finds a weak spot or causes a portion of fascia to slough and so reaches the surface. Accordingly many abscess cavities resulting from deep-seated suppuration are of irregular shape, with pouches and loculi in various directions—an

arrangement which interferes with their successful treatment by incision and drainage.

The relief of tension which follows the bursting of an abscess, the removal of irritation by the escape of pus, and the casting off of bacteria and toxins, allow the tissues once more to assert themselves, and a process of repair sets in. The walls of the abscess fall in; granulation tissue grows into the space and gradually fills it; and later this is replaced by cicatricial tissue. As a result of the subsequent contraction of the cicatricial tissue, the scar is usually depressed below the level of the surrounding skin surface.

If an abscess is prevented from healing—for example, by the presence of a foreign body or a piece of necrosed bone—a sinus results, and from it pus escapes until the foreign body is removed.

Clinical Features of an Acute Circumscribed Abscess.—In the initial stages the usual symptoms of inflammation are present. Increased elevation of temperature, with or without a rigor, progressive leucocytosis, and sweating, mark the transition between inflammation and suppuration. An increasing leucocytosis is evidence that a suppurative process is spreading.

The local symptoms vary with the seat of the abscess. When it is situated superficially—for example, in the breast tissue—the affected area is hot, the redness of inflammation gives place to a dusky purple colour, with a pale, sometimes yellow, spot where the pus is near the surface. The swelling increases in size, the firm brawny centre becomes soft, projects as a cone beyond the level of the rest of the swollen area, and is usually surrounded by a zone of induration.

By gently palpating with the finger-tips over the softened area, a fluid wave may be detected—*fluctuation*—and when present this is a certain indication of the existence of fluid in the swelling. Its recognition, however, is by no means easy, and various fallacies are to be guarded against in applying this test clinically. When, for example, the walls of the abscess are thick and rigid, or when its contents are under excessive tension, the fluid wave cannot be elicited. On the other hand, a sensation closely resembling fluctuation may often be recognised in œdematous tissues, in certain soft, solid tumours such as fatty tumours or vascular sarcomata, in aneurysm, and in a muscle when it is palpated in its transverse axis.

When pus has formed in deeper parts, and before it has

reached the surface, œdema of the overlying skin is frequently present, and the skin pits on pressure.

With the formation of pus the continuous burning or boring pain of inflammation assumes a throbbing character, with occasional sharp, lancinating twinges. Should doubt remain as to the presence of pus, recourse may be had to the use of an exploring needle.

Differential Diagnosis of Acute Abscess.—A practical difficulty which frequently arises is to decide whether or not pus has actually formed. It may be accepted as a working rule in practice that when an acute inflammation has lasted for four or five days without showing signs of abatement, suppuration has almost certainly occurred. In deep-seated suppuration, marked œdema of the skin and the occurrence of rigors and sweating may be taken to indicate the formation of pus.

There are cases on record where rapidly growing sarcomatous and angiomatous tumours, aneurysms, and the bruises that occur in hæmophylics, have been mistaken for acute abscesses and incised, with disastrous results.

Treatment of Acute Abscess.—The dictum of John Bell, "Where there is pus, let it out," summarises the treatment of abscess. The extent and situation of the incision and the means taken to drain the cavity, however, vary with the nature, site, and relations of the abscess. In a superficial abscess, for example a bubo, or an abscess in the breast or face, where a disfiguring scar is undesirable, a small puncture should be made where the pus threatens to point, and a Klapp's suction bell be applied as already described (p. 48). A drain is not necessary, and in the intervals between the applications of the bell the part is covered by a moist antiseptic dressing.

In abscesses deeply placed, as for example under the gluteal or pectoral muscles, one or more incisions should be made, and the cavity drained by glass or rubber tubes or by strips of rubber tissue.

The wound should be dressed the next day, and the tube shortened, in the case of a rubber tube, by cutting off a portion of its outer end. On the second day or later, according to circumstances, the tube is removed, and after this the dressing need not be repeated oftener than every second or third day.

Where pus has formed in relation to important structures—as for example in the deeper planes of the neck—*Hilton's*

method of opening the abscess may be employed. An incision is made through the skin and fascia, a grooved director is gently pushed through the deeper tissues till pus escapes along its groove, and then the track is widened by passing in a pair of dressing forceps and expanding the blades. A tube, or strip of rubber tissue, is introduced, and the subsequent treatment carried out as in other abscesses. When the drain lies in proximity to a large blood-vessel, care must be taken not to leave it in position long enough to cause ulceration of the vessel wall by pressure.

In some abscesses, such as those in the vicinity of the anus, the cavity should be laid freely open in its whole extent, stuffed with iodoform gauze, and treated by the open method.

It is seldom advisable to wash out an abscess cavity, and squeezing out the pus is also to be avoided, lest the protective zone be broken down and the infection be diffused into the surrounding tissues.

The importance of adopting antiseptic precautions in opening an abscess can scarcely be exaggerated, and the rapidity with which healing occurs when the access of fresh bacteria is prevented is in marked contrast to what occurs when antiseptic precautions are neglected and further infection is allowed to take place.

Acute Suppuration in a Wound.—If in the course of a surgical operation bacterial infection of the wound has occurred, a marked inflammatory reaction soon manifests itself, and the same pathological changes as occur in the formation of an acute abscess take place, modified, however, by the fact that the pus can more readily reach the surface. In from twenty-four to forty-eight hours after the operation the patient is conscious of a sensation of chilliness, or may even have a distinct rigor. At the same time he feels generally out of sorts, with impaired appetite, headache, and it may be looseness of the bowels. His temperature rises to 100° or 101° F., and the pulse quickens to 100 or 110.

On exposing the wound it is found that the parts for some distance around are red, glazed, and œdematous. The discoloration and swelling are most intense in the immediate vicinity of the wound, the edges of which are everted and moist. Any stitches that may have been introduced are tight, and the deep ones may be cutting into the tissues. There is heat, and a constant burning or throbbing pain, which is increased by pressure. If the stitches be cut, pus escapes,

the wound gapes, and its surfaces are found to be covered with granulations bathed in pus.

The open method is the only safe means of treating such wounds. The infected surface may be sponged over with pure carbolic acid, the excess of which is washed off with absolute alcohol, and the wound either drained by tubes or packed with iodoform gauze. The practice of scraping such surfaces with the sharp spoon, squeezing or even of washing them out with antiseptic lotions, is attended with the risk of further diffusing the organisms in the tissue, and is only to be employed under exceptional circumstances. Continuous irrigation of septic wounds or their immersion in antiseptic baths is sometimes useful. The free opening up of the wound is almost immediately followed by a fall in the temperature. The surrounding inflammation subsides, the discharge of pus lessens, and healing takes place by the formation of granulation tissue—the so-called “healing by second intention.”

Wound infection may take place from *catgut* which has not been perfectly prepared. The local and general reactions may be very slight, and, as a rule, do not appear for seven or eight days after the operation, and, it may be, not till after the skin edges have united. The suppuration is strictly localised to the part of the wound where *catgut* was employed for stitches or ligatures, and shows little tendency to spread. The infected part, however, is often long of healing. The irritation in these cases is probably due to toxins in the *catgut* and not to bacteria; this being an example of “aseptic suppuration.”

When suppuration occurs in connection with buried sutures of unabsorbable materials, such as silk, silkworm gut, or silver wire, it is apt to persist till the foreign material is cast off or removed.

Suppuration may occur in the track of skin stitches, producing *stitch abscesses*. The infection may arise from the material used, especially *catgut* or silk, or, more frequently perhaps, from the growth of *staphylococcus albus* from the skin of the patient when this has been imperfectly disinfected.

Acute Suppuration of a Mucous Membrane.—When pyogenic organisms gain access to a mucous membrane, such as that of the bladder, urethra, or middle ear, the usual phenomena of acute inflammation and suppuration ensue, followed by the discharge of pus on the free surface. It would appear that the most marked changes take place in the sub-mucous tissue,

causing the covering epithelium in places to die and leave small superficial ulcers, for example in gonorrheal urethritis, the cicatricial contraction of the scar subsequently leading to the formation of stricture. When mucous glands are present in the membrane, the pus is mixed with mucus—*mucopus*.

DIFFUSE CELLULITIS AND DIFFUSE SUPPURATION

Cellulitis is an acute affection resulting from the introduction of some organism—commonly the *streptococcus pyogenes*—into the cellular connective tissue of the integument, intermuscular septa, tendon sheaths, or other structures. Infection always takes place through a breach of the surface, although this may be superficial and insignificant, such as a pin-prick, a scratch, or a crack under a nail, and the wound may have been healed for some time before the inflammation sets in. The cellulitis, also, may develop at some distance from the seat of inoculation, the organisms having travelled by the lymphatics.

The virulence of the organisms, the loose, open nature of the tissues in which they develop, and the free lymphatic circulation by means of which they are spread, account for the diffuse nature of the process. Sometimes numbers of cocci are carried for a considerable distance from the primary area before they are arrested in the lymphatics, and thus several patches of inflammation may appear with healthy areas between.

The pus infiltrates the meshes of the cellular tissue, there is sloughing of considerable portions of tissue of low vitality, such as fat, fascia, or tendon, and if the process continues for some time several collections of pus may form.

Clinical Features.—The general reaction in cases of diffuse cellulitis is severe, and is usually ushered in by a distinct chill or even a rigor, while the temperature rises to 103°, 104°, or 105° F. The pulse is proportionately increased in frequency, and is small, feeble, and often irregular. The face is flushed, the tongue dry and brown, and the patient may become delirious, especially during the night. Leucocytosis is present in cases of moderate severity; but in severe cases the virulence of the toxins prevents reaction taking place, and leucocytosis is absent.

The local manifestations vary with the relation of the seat of the inflammation to the surface. When the superficial cellular tissue is involved, the skin assumes a dark bluish-red colour, is

swollen, œdematous, and the seat of burning pain. To the touch it is firm, hot, and tender. When the primary focus is in the deeper tissues, the general constitutional disturbance is aggravated, while the local signs are delayed, and only become prominent when pus forms and approaches the surface. It is not uncommon for blebs containing dark serous fluid to form on the skin. The infection frequently spreads along the line of the main lymphatic vessels of the part (*septic lymphangitis*), and may reach the lymphatic glands (*septic lymphadenitis*).

With the formation of pus the skin becomes soft and boggy at several points, and eventually breaks, giving exit to a quantity of thick, grumous discharge. Sometimes several small collections under the skin fuse, and an abscess is formed, in which fluctuation can be detected. Occasionally gases are evolved in the tissues, giving rise to emphysema. It is common for portions of fascia, ligaments, or tendons to slough, and this may often be recognised clinically by a peculiar crunching or grating sensation transmitted to the fingers on making firm pressure on the part.

If it is not let out by incision, the pus, travelling along the lines of least resistance, tends to point at several places on the surface, or to open into joints or other cavities.

Prognosis.—The occurrence of *septicæmia* is the most serious risk, and it is in cases of diffuse suppurative cellulitis that this form of blood-poisoning assumes its most aggravated forms. The toxins of the streptococci are exceedingly virulent, and induce local death of tissue so rapidly that the protective emigration of leucocytes fails to take place. In some cases the passage of masses of free cocci in the lymphatics, or of septic emboli in the blood-vessels, leads to the formation of *pyæmic abscesses* in vital organs, such as the brain, lungs, liver, kidneys, or other viscera. *Hæmorrhage* from erosion of arterial or venous trunks may take place and endanger life.

Treatment.—The treatment of diffuse cellulitis depends to a large extent on the situation and extent of the affected area, and on the stage of the process.

In the limbs, for example, where the application of a constricting band is practicable, Bier's method of inducing passive hyperæmia yields excellent results. If pus has formed, one or more small incisions are made and a light moist dressing placed over the wounds to absorb the discharge, but no drain is inserted. The dressing is changed as often as necessary, and in the intervals when the band is off, gentle active and passive movements should be carried out to prevent

the formation of adhesions. After incisions have been made, we have found the *immersion* of the limb, for a few hours at a time, in a water-bath containing warm boracic lotion a useful adjuvant to the passive hyperæmia.

Continuous irrigation of the part by a slow, steady stream of lotion, at the body temperature, such as boracic acid or permanganate of potash, or frequent washing with sulphurous acid or peroxide of hydrogen, has been found of value in some cases.

A suitably arranged splint adds to the comfort of the patient; and the limb should be placed in the attitude which, in the event of stiffness resulting, will least interfere with its usefulness. The elbow, for example, should be flexed to a little less than a right angle; at the wrist, the hand should be dorsiflexed and the fingers flexed slightly towards the palm.

Massage, passive movement, hot and cold douching, and other measures, may be necessary to get rid of the chronic œdema, adhesions of tendons, and stiffness of joints which sometimes remain.

In situations where a constricting band cannot be applied, for example on the trunk or the neck, Klapp's suction bells may be used, small incisions being made to admit of the escape of the pus.

If these measures fail or are impracticable, it may be necessary to make one or more free incisions, and to insert drainage-tubes or iodoform worsted.

The general treatment of toxæmia must be carried out, and in cases due to infection by streptococci, anti-streptococcic serum may be used.

In a few cases, amputation well above the seat of disease may, by removing the source of toxin production, offer the only means of saving the patient.

WHITLOW

The clinical term whitlow is applied to an acute septic infection, usually followed by suppuration, commonly met with in the fingers, less frequently in the toes. The point of infection is often very trivial—a pin-prick, a puncture caused by a splinter of wood, a scratch, or even an imperceptible lesion of the skin.

Several varieties of whitlow are recognised, but while it is convenient to describe them separately, it is to be clearly understood that clinically they merge one into another, and it

is not always possible to determine in which connective-tissue plane a given infection has originated.

Initial Stage.—Attention is usually first attracted to the condition by a sensation of tightness in the finger and tenderness when the part is squeezed or knocked against anything. In the course of a few hours the part becomes red and swollen; there is continuous pain, which soon assumes a throbbing character, particularly when the hand is dependent, and may be so severe as to prevent sleep, and the patient may feel generally out of sorts.

If a constricting band is applied at this stage, the infection can usually be checked and the occurrence of suppuration prevented. If this fails, or if the condition is allowed to go untreated, the inflammatory reaction increases and terminates in suppuration, giving rise to one or other of the forms of whitlow to be described.

The Purulent Blister.—In the most superficial variety, pus forms between the rete Malpighii and the stratum corneum of the skin, the latter being raised as a blister in which fluctuation can be detected (Fig. 16, *a*). This is commonly met with in the palm of the hand of labouring men who have recently resumed work after a spell of idleness. When the blister forms near the tip of the finger, the pus burrows under the nail,—which corresponds to the stratum corneum,—raising it from its bed.

There is some local heat and discoloration, and considerable pain and tenderness, but little or no constitutional disturbance. Superficial lymphangitis may extend a short distance up the hand. By clipping away the raised epidermis, and if necessary the nail, the pus is allowed to escape, and healing speedily takes place.

Whitlow at the Nail Fold.—This variety, which is met with among those who handle septic material, occurs in the sulcus between the nail and the skin, and is due to the introduction of septic matter at the root of the nail (Fig. 16, *b*). A small focus of suppuration forms under the nail, with swelling and redness of the nail fold, causing intense pain and discomfort, interfering with sleep, and producing a constitutional reaction out of all proportion to the local lesion.

To allow the pus to escape, it is necessary, under local anæsthesia, to cut away the nail fold as well as the portion of nail in the affected area, or, it may be, to remove the nail entirely. If only a small opening is made in the nail it is apt to be blocked by granulations.

Subcutaneous Whitlow.—In this variety the disease manifests itself as a cellulitis of the pulp of the finger (Fig. 16, *c*), which sometimes spreads towards the palm of the hand. The finger becomes red, swollen, and tense; there is severe throbbing pain, which is usually worst at night and prevents sleep, and the part is extremely tender on pressure. When the palm is invaded, there may be marked œdema of the back of the hand, the dense integument of the palm preventing the swelling from appearing on the front until the pus is nearing the surface. The pus may be under such tension that fluctuation cannot be detected. The patient is usually able to flex the finger to a certain extent without increasing the pain—a point which indicates that the tendon sheaths have not been invaded.

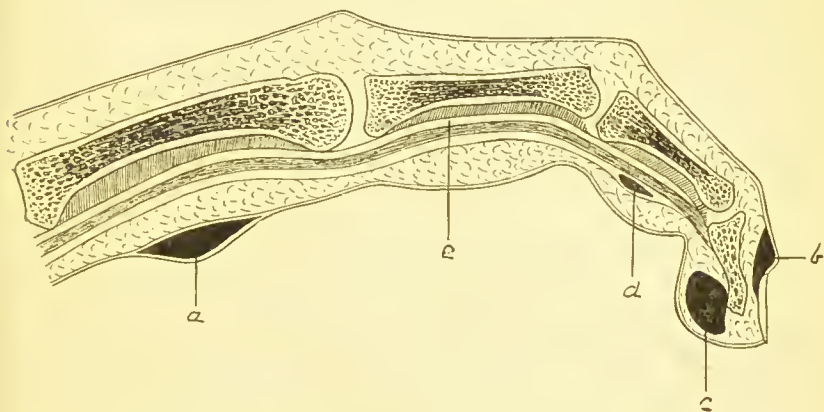


FIG. 16.—Diagram of various forms of Whitlow.

- a* = Purulent blister.
- b* = Suppuration at nail fold.
- c* = Subcutaneous whitlow.
- d* = Whitlow in sheath of flexor tendon (*e*).

The suppurative process may, however, spread to the tendon sheaths, or even to the bone. Sometimes the excessive tension and virulent toxins induce actual gangrene of the distal part, or even of the whole finger. There is considerable constitutional disturbance, the temperature often reaching 101° or 102° F.

The treatment consists in applying a constriction band and making an incision over the centre of the most tender area, care being taken to avoid opening the tendon sheath, lest the infection be conveyed to it. Moist dressings should be employed while the suppuration lasts. Carbolic fomentations, however, are to be avoided on account of the risk of inducing gangrene.

Whitlow of the Tendon Sheaths.—In this form the main incidence of the infection is on the sheaths of the flexor tendons, but it is not always possible to determine whether it started there or spread thither from the subcutaneous cellular tissue (Fig. 16, *d*). In some cases both connective-tissue planes are involved. The affected finger becomes red, painful, and swollen, the swelling spreading to the dorsum. The involvement of the tendon sheath is usually indicated by the patient being unable to flex the finger and by the pain being increased when he attempts to do so. On account of the anatomical arrangement of the tendon sheaths, the process may spread into the forearm—directly in the case of the thumb and little finger, and after invading the palm in the case of the other fingers—and there give rise to a diffuse cellulitis which may result in sloughing of fasciæ and tendons. When the infection spreads into the common flexor sheath under the anterior annular ligament, it is not uncommon for the intercarpal and wrist joints to become implicated. Impaired movement of tendons and joints is, therefore, a common sequel to this variety of whitlow.

The *treatment* consists in inducing passive hyperæmia by Bier's method, and, if this is done early, suppuration may be avoided. If pus forms, small incisions are made, under local anæsthesia, to relieve the tension in the sheath and to diminish the risk of the tendons sloughing. No form of drain should be inserted. In the fingers the incisions should be made in the middle line to avoid the digital vessels and nerves; in the palm they should be made over the metacarpal bones to avoid the digital vessels and nerves. If pus has spread under the anterior annular ligament, the incision should be placed over the middle of the front of the wrist. Passive movements and massage must be commenced as early as possible and be perseveringly employed, to prevent the formation of adhesions and resulting stiffness.

Subperiosteal Whitlow—This form is usually an extension of the subcutaneous or of the thecal variety, but in some cases the inflammation begins in the periosteum—usually of the terminal phalanx. It may lead to necrosis of a portion or even of the entire phalanx. This is usually recognised by the persistence of suppuration long after the acute symptoms have passed off, and by feeling bare bone with the probe. In such cases one or more of the joints are usually implicated also, and lateral mobility and grating may be elicited on manipulation. Recovery does not take place until the dead bone is removed,

and the usefulness of the finger is often seriously impaired by fibrous or bony ankylosis of the interphalangeal joints. This may render amputation advisable when a stiff finger is likely to interfere with the patient's occupation.

SUPPURATIVE CELLULITIS IN DIFFERENT SITUATIONS

Cellulitis of the forearm is usually a sequel to one of the deeper varieties of whitlow.

In the *region of the elbow-joint*, cellulitis is common around the olecranon process. It may originate as an inflammation of the olecranon bursa, or may invade the bursa secondarily. In exceptional cases the elbow-joint is also involved.

Cellulitis of the *axilla* may originate in suppuration in the lymphatic glands, following an infected wound of the hand, or it may spread from a septic wound on the chest wall or in the neck. In some cases it is impossible to discover the primary seat of infection. A firm, brawny swelling forms in the armpit and extends on to the chest wall. It is attended with great pain, which is increased on moving the arm, and there is marked constitutional disturbance. When suppuration occurs, its spread is limited by the attachments of the axillary fascia, and the pus tends to burrow on to the chest wall beneath the pectoral muscles, and upwards towards the shoulder-joint, into which it may burst and so give rise to a septic arthritis. When the pus forms in the axillary space, the treatment consists in making free incisions, which should be placed on the thoracic side of the axilla to avoid the axillary vessels and nerves. If the pus spreads on to the chest wall, the abscess should be opened below the clavicle by Hilton's method, and a counter opening may be made in the axilla.

Cellulitis of the *sole of the foot* may follow whitlow of the toes.

In the *region of the ankle* cellulitis is not common; but *around the knee* it frequently occurs in relation to the prepatellar bursa and to the popliteal lymphatic glands, and may endanger the knee-joint. It is also met with in the *groin* following on inflammation and suppuration of the inguinal glands, and cases are recorded in which the sloughing process has implicated the femoral vessels and led to secondary hæmorrhage.

Cellulitis of the scalp, orbit, neck, pelvis, and perineum will be considered with the diseases of these regions.

CHRONIC SUPPURATION

While it is true that a chronic pyogenic abscess is sometimes met with—for example, in the breast and in the marrow of long bones—in the great majority of instances the formation of a chronic or cold abscess is the result of the action of the tubercle bacillus. It is therefore more convenient to study this form of suppuration with tuberculosis, and the reader is referred to the chapter on that subject.

LOCAL RESULTS OF SUPPURATION WHEN HEALING IS
PREVENTED—SINUS AND FISTULA

A **Sinus** is a track leading from a focus of suppuration in the tissues to a cutaneous or mucous surface. There are two varieties of sinus met with clinically—the septic and the tuberculous.

A *septic sinus* usually represents the track by which the discharge escapes from an abscess cavity which has been prevented from closing completely. The obstacle to closure may be the rigidity of the walls of the cavity as in empyema, the presence of a foreign body, such as a piece of dead bone, a septic ligature, or a bullet in the abscess cavity, and this may act mechanically or by keeping up a discharge which must find an exit. In other cases—for example, when the sinus passes through a muscle—closure may be prevented by the constant movement of the part. The sinus is lined by granulation tissue, and when a foreign body is present a mass of redundant granulations often projects from the external opening. In a sinus of long standing there is often a considerable amount of scar tissue around it, the contraction of which drags the opening of the sinus below the level of the surrounding skin. The *treatment* in these cases is the removal of the cause, by enlarging the opening so as to be able to remove any foreign substance, and to permit of disinfection as well as of thorough drainage. Any muscles through or between which the sinus passes must be kept at rest by suitable splints, or by division of their fibres. The sinus may be scraped, and treated with pure carbolic acid or the thermo-cautery, and then stuffed with iodoform worsted, so as to encourage healing from the bottom. When the healing of a sinus is likely to be followed by contraction causing disfigurement—for example, in a sinus over the lower jaw associated with a carious tooth—it may be completely excised, the raw surfaces being approximated by stitches.

The *tuberculous sinus* is described under Tuberculosis.

A **Fistula** is an abnormal canal passing from a mucous surface to the skin or to another mucous surface. Fistulæ resulting from suppuration usually occur near the natural openings of mucous canals—for example, on the cheek, as a salivary fistula; beside the inner angle of the eye, as a lachrymal fistula; near the ear, as a mastoid fistula; or close to the anus, as a fistula-in-ano. Intestinal fistulæ are sometimes met with in the abdominal wall after strangulated hernia, operations for appendicitis, tuberculous peritonitis, and other conditions. In the perineum, fistulæ frequently complicate stricture of the urethra.

Fistulæ also occur between the bladder and vagina (*vesico-vaginal fistula*), or between the bladder and the rectum (*recto-vesical fistula*).

The *treatment* of these various forms of fistula will be described in the sections dealing with the regions in which they occur.

Congenital fistulæ, such as occur in the neck from imperfect closure of branchial clefts, or in the abdomen from unobliterated foetal ducts such as the urachus or Meckel's diverticulum, will be described in their proper places.

CONSTITUTIONAL MANIFESTATIONS OF PYOGENIC INFECTION

We have here to consider under the terms Sapræmia, Septicæmia, and Pyæmia certain general effects of pyogenic infection, which, although their clinical manifestations may vary, are all associated with the action of the same forms of bacteria. They may occur separately or in combination, or one may follow on and merge into another.

Sapræmia, or septic intoxication, is the name applied to a form of septic poisoning resulting from the absorption into the blood of the toxic products of pyogenic bacteria. These products, which are of the nature of alkaloids, act immediately on their entrance into the circulation, and produce effects in direct proportion to the amount absorbed. As the poison is gradually eliminated from the body the symptoms abate, and if no more is introduced they disappear. Sapræmia in these respects, therefore, is comparable to poisoning by any other form of alkaloid, such as strychnin or morphin.

Clinical Features.—The symptoms of sapræmia seldom manifest themselves within twenty-four hours of an operation or injury, because it takes some time for the bacteria to produce

a sufficient dose of their poisons. The onset of the condition is marked by a feeling of chilliness, sometimes amounting to a rigor, and a rise of temperature to 102° , 103° , or 104° F., with slight morning remissions (Fig. 5). The heart's action is markedly depressed, and the pulse is soft and compressible. The appetite is lost, the tongue dry and covered with a thin brownish-red fur, so that it has the appearance of "dried beef." The urine is scanty and loaded with urates. In severe cases diarrhœa and vomiting of dark coffee-ground material are often prominent features. Death is usually impending when the skin becomes cold and clammy, the mucous membranes livid, the pulse feeble and fluttering, the discharges involuntary, and when a low form of muttering delirium is present.

A local focus of septic infection is always present,—it may be an abscess, a septic compound fracture, or a septic infection of the cavity of the uterus, for example, from a retained portion of placenta.

Treatment.—The first indication is the immediate and complete removal of the infected material. The wound must be freely opened, all blood-clot, discharge, or necrosed tissue removed, and the area disinfected, by washing with sterilised salt solution, peroxide of hydrogen, or boracic lotion. Stronger lotions are to be avoided as being likely to depress the tissues, and so to interfere with protective phagocytosis. On account of its power of neutralising toxins, iodoform is useful in these cases, and is best employed by packing the wound with iodoform gauze, and treating it by the open method, if this is possible.

The general treatment is carried out on the same lines as for other infective conditions.

Chronic Sapræmia or Hectic Fever.—Hectic fever differs from acute sapræmia merely in degree. It usually occurs in connection with tuberculous conditions such as bone or joint disease, psoas abscess, or empyema, which have opened externally, and have thereby become infected with pyogenic organisms. It is gradual in its development, and is of a mild type throughout.

The pulse is small, feeble, and compressible, and the temperature rises in the afternoon or evening to 102° or 103° F. (Fig. 6), the cheeks becoming characteristically flushed. In the early morning the temperature suddenly falls to normal or below it, and the patient breaks into a profuse perspiration, which leaves him pale, weak, and exhausted. He becomes rapidly

and markedly emaciated, even although in some cases the appetite remains good and is even voracious.

The poisons circulating in the blood produce *waxy degeneration* in certain viscera, notably the liver, spleen, kidneys, and intestines. The process begins in the arterial walls, and spreads thence to the connective-tissue structures, causing marked enlargement of the affected organs. Albuminuria, ascites, œdema of the lower limbs, clubbing of the fingers, and diarrhœa are among the most prominent symptoms of this condition.

The *prognosis* in hectic fever depends on the completeness with which the further absorption of toxins can be prevented. In many cases this can only be effected by an operation which provides for free drainage, and, if possible, the removal of infected tissues. The resulting wound is best treated by the open method. Even advanced waxy degeneration does not contraindicate this line of treatment, as the diseased organs usually recover if the focus from which absorption of septic material is taking place is completely eradicated.

Septicæmia.—This form of septic poisoning is the result of the action of pyogenic bacteria, which not only produce their toxins at the primary seat of infection, but themselves enter the blood-stream and are carried to other parts, where they settle and produce further effects.

Clinical Features.—There may be an incubation period of some hours between the infection and the first manifestation of acute septicæmia. In such conditions as acute osteomyelitis or acute perforation peritonitis, we see the most typical clinical pictures of this condition. The onset is marked by a chill, or a rigor, which may be repeated, while the temperature rises to 103° or 104° F., although in very severe cases the temperature may remain subnormal throughout, the virulence of the toxins preventing reaction. It is in the general appearance of the patient and in the condition of the pulse that we have our best guides as to the severity of the condition. If the pulse remains firm, full, and regular, and does not exceed 110 or even 120, while the temperature is moderately raised, the outlook is hopeful; but when the pulse becomes small and compressible, and reaches 130 or more, especially if at the same time the temperature is low, a grave prognosis is indicated. The tongue is often dry and coated with a black crust down the centre, while the sides are red. It is a good omen when the tongue becomes moist again. Thirst is most distressing, especially in septicæmia of intestinal origin. Persistent vomiting of dark-brown material is often present, and diarrhœa with blood-stained

stools is not uncommon. The urine is small in amount, and contains a large proportion of urates. As the poisons accumulate, the respiration becomes shallow and laboured, the face of a dull ashy grey, the nose pinched, and the skin cold and clammy. Capillary hæmorrhages sometimes take place in the skin or mucous membranes; and in a certain proportion of cases cutaneous eruptions simulating those of scarlet fever or measles appear, and are apt to lead to errors in diagnosis. In other cases there is slight jaundice. The mental state is often one of complete apathy, the patient failing to realise the gravity of his condition; sometimes there is delirium.

The *prognosis* is always grave, and depends on the possibility of completely eradicating the focus of infection, and on the reserve force the patient has to carry him over the period during which he is eliminating the poison already circulating in his blood.

The treatment is carried out on the same lines as in sapræmia, but is less likely to be successful owing to the organisms having entered the circulation. When possible the primary focus of infection should be dealt with.

Pyæmia is a form of septic poisoning characterised by the development of secondary foci of suppuration in different parts of the body. Toxins are thus introduced into the blood, not only at the primary seat of infection, but also from each of these metastatic collections. Like septicæmia, this condition is due to pyogenic bacteria, the *streptococcus pyogenes* being the commonest organism found. The primary infection is usually in a wound,—for example, a compound fracture,—but cases occur in which the point of entrance of the bacteria is not discoverable. The dissemination of the organisms takes place through the medium of septic emboli which form in a thrombosed vein in the vicinity of the original lesion, and breaking loose are carried thence in the blood-stream. These emboli lodge in the minute vessels of the lungs, spleen, liver, kidneys, pleura, brain, synovial membranes, or cellular tissue, and the bacteria they contain give rise to secondary foci of suppuration. Secondary abscesses are thus formed in those parts, and these in turn may be the starting-point of new emboli which give rise to fresh areas of pus formation. The organs above named are the commonest situations of pyæmic abscesses, but these may also occur in the bone marrow, the substance of muscles, the heart and pericardium, lymphatic glands, subcutaneous tissue, or, in fact, in any tissue of the body. Septic organisms circulating in the blood are prone

to lodge on the valves of the heart and give rise to endocarditis.

Clinical Features.—Before antiseptic surgery was practised, pyæmia was a common complication of surgical wounds. In the present day it is not only infinitely less common, but appears also to be of a less severe type. Its rarity and its mildness may be related as cause and effect, because it was formerly found that pyæmia contracted from a pyæmic patient was more virulent than that from other sources.

In contrast with sapræmia and septicæmia, pyæmia is late of developing, and it seldom begins within a week of the primary infection. The first sign is a feeling of chilliness, or a violent rigor lasting for perhaps half an hour, during which time the temperature rises to 103°, 104°, or 105° F. In the course of an hour it begins to fall again, and the patient breaks into a profuse sweat. The temperature may fall several degrees, but seldom reaches the normal. In a few days there is a second rigor with rise of temperature, and another remission, and such attacks may be repeated at diminishing intervals during the course of the illness (Figs. 8 and 9). The pulse is soft, and tends to remain abnormally rapid even when the temperature falls nearly to normal.

The face is flushed, and wears a drawn, anxious expression, and the eyes are bright. A characteristic sweetish odour, which has been compared to that of new-mown hay, can be detected in the breath and may pervade the patient. The appetite is lost; there may be sickness and vomiting and profuse diarrhœa; and the patient emaciates rapidly. The skin is continuously hot, and has often a peculiar pungent feel. Patches of erythema sometimes appear scattered over the body. The skin may assume a dull sallow or earthy hue, or a bright yellow icteric tint may appear. The conjunctivæ also may be yellow. In the later stages of the disease the pulse becomes small and fluttering; the tongue becomes dry and brown; sordes collect on the teeth; and a low muttering form of delirium supervenes.

Secondary infection of the parotid gland frequently occurs, and gives rise to a suppurative parotitis. This condition is associated with severe pain, gradually extending from behind the angle of the jaw on to the face. There is also swelling over the gland, and eventually suppuration and sloughing of the gland tissue and overlying skin.

Secondary abscesses in the lymphatic glands, subcutaneous tissue, or joints are often so very insidious and painless in

their development that they are only discovered accidentally. When the abscess is evacuated, healing often takes place with remarkable rapidity, and with little interference with function.

Prognosis.—The prognosis in acute pyæmia is much less hopeless than it once was, a considerable proportion of the patients recovering. In acute cases the disease proves fatal in ten days or a fortnight, death being due to toxæmia. Chronic cases often run a long course, lasting for weeks or even months, and prove fatal from exhaustion and waxy disease following on prolonged suppuration.

Treatment.—In such conditions as compound fractures and severe lacerated wounds, much can be done to avert the conditions which lead to pyæmia, by applying a Bier's constricting bandage as soon as there is evidence of infection having taken place, or even if there is reason to suspect that the wound is not aseptic.

If sepsis is already established, and evidence of general infection is present, the wound should be opened up sufficiently to admit of thorough disinfection and drainage, and the constricting bandage applied to aid the defensive processes going on in the tissues. If these measures fail, amputation of the limb may be the only means of preventing further dissemination of infective material from the primary source of infection.

Attempts have been made to interrupt the channel along which the septic emboli spread, by ligating or resecting the main vein of the affected part, but this is seldom feasible except in the case of the internal jugular vein for lateral sinus phlebitis.

Secondary abscesses must be aspirated or opened and drained whenever possible.

The general treatment is conducted on the same lines as in other forms of septic infection.

CHAPTER VI

ULCERATION AND ULCERS

Definitions—Clinical examination of an ulcer—The healing sore.—Classification of ulcers—A. According to cause: *Traumatism, Imperfect circulation, Imperfect nerve-supply, Constitutional causes*—B. According to condition: *Healing, Stationary, Spreading*.—Treatment—SKIN-GRAFTING.

THE process of *ulceration* may be defined as the molecular or cellular death of tissue taking place on a free surface. It is essentially of the same nature as the process of suppuration, only that the purulent discharge, instead of collecting in a closed cavity and forming an abscess, at once escapes on the surface.

An *ulcer* is an open wound or sore in which there are present certain conditions tending to prevent it undergoing the natural process of repair. Of these, one of the most important is the presence of pathogenic bacteria, which by their action not only prevent healing, but so irritate and destroy the tissues as to lead to an actual increase in the size of the sore. Interference with the nutrition of a part by œdema or chronic venous congestion may impede healing; as may also induration of the area surrounding an ulcer, by preventing the contraction which is such an important factor in repair. Defective innervation, such as occurs in injuries and diseases of the spinal cord, also plays an important part in delaying repair. In certain constitutional conditions, too—for example, Bright's disease, diabetes, or syphilis—the vitiated state of the tissues is an impediment to repair. Mechanical causes, such as unsuitable dressings or ill-fitting appliances, may also act in the same direction.

Clinical Examination of an Ulcer.—In examining any ulcer, we observe—(1) Its *base* or *floor*, noting the presence or absence of granulations, their disposition, size, colour, vascularity, and whether they are depressed or elevated in relation

to the surrounding parts. (2) The *discharge* as to quantity, consistence, colour, composition, and odour. (3) The *edges*, noting particularly whether or-not the marginal epithelium is attempting to grow in over the surface; also their shape, regularity, thickness, and whether undermined or overlapping, everted or depressed. (4) The *surrounding tissues* as to whether they are congested, œdematous, inflamed, indurated, or otherwise. (5) Whether or not there is *pain* or tenderness in the raw surface or its surroundings. (6) The *part of the body* on which it occurs, because certain ulcers have special seats of election—for example, the varicose ulcer in the lower third of the leg, the perforating ulcer on the sole of the foot, and so on.

The Healing Sore.—If a portion of skin be excised aseptically, and no attempt made to close the wound, the raw surface left is soon covered over with a layer of coagulated blood and lymph. In the course of a few days this is replaced by the growth of *granulations*, which are of uniform size, of a pinkish-red colour, and moist with a slight serous exudate containing a few dead leucocytes. They grow until they reach the level of the surrounding skin, and so fill the gap with a fine velvety mass of granulation tissue. At the edges, the young epithelium may be seen spreading in over the granulations as a fine bluish-white pellicle, which gradually covers in the sore, becoming paler in colour as it thickens, and eventually forming the smooth, non-vascular covering of the cicatrix. There is no pain, and the surrounding parts are healthy.

This may be used as a type with which to compare the ulcers seen at the bedside, so that we may determine how far, and in what particulars, these differ from the type; and that we may in addition recognise the conditions that have to be counteracted before the characters of the typical healing sore are assumed.

For purposes of contrast we may indicate the characters of an open sore in which bacterial infection with pathogenic bacteria has taken place. The layer of coagulated blood and lymph becomes liquefied and is thrown off, and instead of granulations being formed, the tissues exposed on the floor of the ulcer are destroyed by the bacterial toxins, with the formation of minute sloughs and a quantity of pus.

The discharge is profuse, thin, acrid, and offensive, and consists of pus, broken-down blood-clot, and sloughs. The edges are inflamed, irregular, and ragged, showing no sign of growing epithelium,—on the contrary, the sore may be actually increasing in area by the breaking-down of the tissues at its margins.

The surrounding parts are hot, red, swollen, and œdematous; and there is pain and tenderness both in the sore itself and in the parts around.

Classification of Ulcers.—The nomenclature of ulcers is much involved and gives rise to great confusion, chiefly for the reason that no one basis of classification has been adopted. Thus some ulcers are named according to the causes at work in producing or maintaining them—for example, the traumatic, the septic, and the varicose ulcer; some from the constitutional element present, as the tuberculous, the syphilitic, the gouty, and the diabetic ulcer; and others according to the condition in which they happen to be when seen by the surgeon, such as the weak, the inflamed, and the callous ulcer.

So long as we retain these names it will be impossible to find a single basis for classification; and yet many of the terms are so descriptive and so generally understood that it is undesirable to abolish them. We must therefore remain content with a clinical arrangement of ulcers—it cannot be called a classification,—considering any given ulcer from two points of view: first its *cause*, and second its *present condition*. This method of studying ulcers has the practical advantage that it furnishes us with the main indications for treatment as well as for diagnosis,—the cause must be removed, and the condition so modified as to convert the ulcer into an aseptic healing sore.

A. Arrangement of Ulcers according to their Cause.—Although any given ulcer may be due to a combination of causes, it is convenient to describe the following groups.

Ulcers due to Traumatism.—Traumatism in the form of a *crush* or *bruise* is a frequent cause of ulcer formation, acting either by directly destroying the skin, or by so diminishing its vitality that it is rendered a suitable soil for bacteria. If these gain access, in the course of a few days the damaged area of skin becomes of a greyish colour, blebs form on it, and it sloughs, leaving an unhealthy raw surface when the slough separates.

Heat and exposure to the Röntgen rays act in a similar way.

The *pressure* of improperly padded splints or other appliances may so far interfere with the local circulation of the part pressed upon, that the skin sloughs, leaving an open sore. This is most liable to occur in patients who suffer from some nerve lesion—such as anterior poliomyelitis, or injury of the spinal cord or nerve-trunks. Splint-pressure sores are usually situated over bony prominences, such as the malleoli, the condyles of the

femur or humerus, the head of the fibula, the dorsum of the foot, or the base of the fifth metatarsal bone. On removing



FIG. 17.—Leg Ulcers associated with Varicose Veins and Pigmentation of the Skin.

the splint, the skin of the part pressed upon is found to be of a red or pink colour, with a pale grey patch in the centre, which eventually sloughs and leaves an ulcer. Certain forms of *bed-sore* are due to prolonged pressure.

Pressure sores are also known to have been produced artificially by malingerers and hysterical subjects.

Ulcers due to Imperfect Circulation.—Imperfect circulation is an important causative factor in ulceration, especially when it is the *venous return* that is defective. This is best illustrated in the so-called *leg ulcer*, which occurs most frequently on the front and inner aspect of the lower third of the leg. At this point the anastomosis between the superficial and deep veins of the leg is less free than elsewhere, so that the extra stress thrown upon the surface veins interferes with the nutrition of the skin (Hilton). The importance of imperfect venous return in the causation of such ulcers is evidenced by the fact that as soon as the condition of the circulation is improved by confining the patient to bed and elevating the limb, the ulcer begins to heal, even although all methods of local treatment have hitherto proved ineffectual. In a considerable number of cases, but by no means in all, this form of ulcer is associated with the presence of varicose veins, and in such cases it is spoken of as the *varicose ulcer* (Fig. 17). The presence of varicose veins is frequently associated with a diffuse brownish or bluish pigmentation of the skin of the lower third of the leg, or with an obstinate form of eczema (*varicose eczema*), and the scratching or rubbing of the part is very liable to cause a breach of the surface and permit of infection which leads to ulceration. Varicose ulcers may also originate from the bursting of a small peri-phlebitic abscess.

Varicose veins in immediate relation to the base of a large chronic ulcer usually become thrombosed, and in time are reduced to fibrous cords, and therefore in such cases hæmorrhage is not a common complication. In smaller and more superficial ulcers, however, the destructive process is liable to implicate the wall of the vessel before the occurrence of thrombosis, and to lead to profuse and often dangerous bleeding.

These ulcers are at first small and superficial, but from want of care, from continued standing or walking, or from injudicious treatment, they gradually become larger and deeper. They are not infrequently multiple, and this, together with their depth, may lead to their being mistaken for ulcers due to syphilis. The base of the ulcer is covered with imperfectly formed, soft, œdematous granulations, which give off a thin sero-purulent discharge. The edges are slightly inflamed, and show no evidence of healing. The parts around are usually pigmented and slightly œdematous, and as a rule there is little pain. This

variety of ulcer is particularly prone to pass into the condition known as callous.

In *anemic* patients, especially young girls, ulcers are occasionally met with which have many of the clinical characters of those associated with imperfect venous return. They are very slow to heal, and tend to pass into the condition known as weak.

Ulcers due to Interference with Nerve-supply.—Any interference with the nerve-supply of the superficial tissues predisposes to ulceration. For example, *trophic* ulcers are liable



FIG. 18.—Trophic Ulcers of Fingers following Division of Median Nerve above Wrist.

to occur in injuries or diseases of the spinal cord, in cerebral paralysis, in limbs weakened by poliomyelitis, in ascending or peripheral neuritis, or after injuries of nerve-trunks (Fig. 18).

The *acute bed-sore* is a rapidly progressing form of ulceration, often amounting to gangrene, of portions of skin exposed to pressure when their trophic nerve-supply has been interfered with.

The *perforating ulcer of the foot* is a peculiar type of sore which occurs in association with the different forms of peripheral neuritis, and with

various lesions of the brain and spinal cord, such as general paralysis, locomotor ataxia, or syringo-myelia. It also occurs in patients suffering from glycosuria (Fig. 19), and is usually associated with arterio-sclerosis—local or general. Perforating ulcer is met with most frequently under the head of the metatarsal bone of the great toe. A callosity forms and suppuration occurs under it, the pus escaping through a small hole in the centre. So long as the patient continues to go about, the process slowly and gradually spreads deeper and deeper, till eventually the bone or joint is reached, and becomes implicated in the destructive process—hence the term “perforating ulcer.” The

flexor tendons are sometimes destroyed, the toe being dorsiflexed by the unopposed extensors. The depth of the track being so



FIG. 19.—Perforating Ulcer of Foot.

disproportionate to its superficial area, the condition closely simulates a tuberculous sinus, for which it is liable to be mistaken. The raw surface is absolutely insensitive, so that



FIG. 20.—Perforating Ulcers of Sole of Foot.
(From Photograph lent by Mr. J. M. Cotterill.)

the probe can be freely employed without the patient even being aware of it or suffering the least discomfort—a significant fact in diagnosis. The cavity is filled with effete and decomposing epidermis, which has a most offensive odour. The chronic and intractable character of these ulcers is due to interference with the trophic nerve-supply of the parts, and to the fact that the epithelium of the skin grows in and lines the track leading down to the deepest part of the ulcer and so prevents closure. While they are commonest on the sole of the foot and other parts subjected to pressure, perforating ulcers

are met with on the sides and dorsum of the foot and toes, on the hands, and on other parts where no pressure has been exerted.

The *tuberculous ulcer*, so often seen in the neck, in the vicinity of joints, or over the ribs and sternum, usually results from the bursting through the skin of a tuberculous abscess. The base is soft, pale, and covered with feeble granulations and grey shreddy sloughs. The edges are of a dull blue or purple colour, and gradually thin out towards their free margins, and in addition are characteristically undermined, so that a probe can be passed for some distance between the floor of the ulcer and the thinned-out edges. Thin, devitalised tags of skin often stretch from side to side of the ulcer. The outline is irregular; small perforations often occur through the skin, and a thin, watery discharge, containing grey shreds of tuberculous debris, escapes.

Bazin's Disease.—This term is applied to an affection of the skin and subcutaneous

tissue which bears certain resemblances to tuberculosis. It is met with almost exclusively between the knee and the ankle, and it usually affects both legs. It is commonest in young women of delicate constitution, in whose family history there is evidence of a tuberculous taint. The patient often presents other lesions of a tuberculous character, notably enlarged cervical glands and phlyctenular ophthalmia. The tubercle bacillus has rarely been found, but we have always observed characteristic epithelioid cells and giant cells.

The condition begins by the formation in the skin and subcutaneous tissue of dusky or livid nodules of induration,

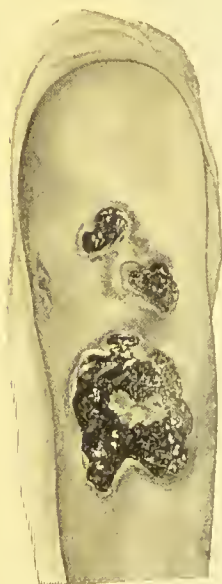


FIG. 21.—Syphilitic Ulcers of Leg.

which soften and ulcerate, forming small open sores with ragged and undermined edges, not unlike those resulting from the breaking down of superficial syphilitic gummata (Fig. 22). Fresh crops of nodules appear in the neighbourhood of the ulcers, and in turn break down. While in the nodular stage the affection is sometimes painful, but with the formation of the ulcers the pain subsides.

The disease runs a very chronic course, and may slowly extend over a wide area in spite of all the usual methods of treatment. After lasting for some months, or even years, however, it may eventually undergo spontaneous cure. The most satisfactory treatment is to excise the affected tissues and fill the gap with Thiersch grafts.

The *syphilitic ulcer* is usually formed by the breaking down of a cutaneous or subcutaneous gumma in the tertiary stage of syphilis. When the gummatous tissue is first exposed by the destruction of the skin or mucous membrane covering it, it appears as a tough greyish



FIG. 22.—Bazin's Disease in a girl æt. 16.

slough, compared to "wash leather," which slowly separates and leaves a more or less circular, deep, punched-out gap which shows a few feeble unhealthy granulations and small sloughs on its floor. The edges are raised and indurated; and the discharge is thick, glairy, and peculiarly offensive. The parts around the ulcer are congested and of a dark-brown colour. There are usually several such ulcers together, and as they tend to heal at one part while they spread at another, the affected area assumes a sinuous or serpiginous outline. Syphilitic ulcers may be met with in any part of the body, but are most frequent

in the upper part of the leg (Fig. 21), especially around the knee-joint in women, and over the ribs and sternum. On healing, they usually leave a depressed and adherent cicatrix.

The *scorbutic ulcer* occurs in patients suffering from scurvy, and is characterised by its prominent granulations, which show a marked tendency to bleed, with the formation of clots, which dry and form a spongy crust on the surface.

In *gouty* patients small ulcers which are exceedingly irritable and painful are liable to occur.

Ulcers associated with Malignant Disease.—Cancer and sarcoma when situated in the subcutaneous tissue may destroy the overlying skin so that the substance of the tumour is exposed. The fungating masses thus produced are sometimes spoken of as malignant ulcers, but as they are essentially different in their nature from all other forms of ulcers, and call for totally different treatment, it is best to consider them along with the tumours with which they are associated. Rodent ulcer, which is one form of cancer of the skin, will be discussed with tumours of the skin.

B. Arrangement of Ulcers according to their Condition.—

Having arrived at an opinion as to the cause of a given ulcer, and placed it in one or other of the preceding groups, the next question to ask is, "In what condition do I find this ulcer at the present moment?"

Any ulcer is in one of three states—healing, stationary, or spreading; although it is not uncommon to find healing going on at one part while the ulcer is extending at another.

The Healing Condition.—The process of healing in an ulcer has already been studied, and we have learned that it takes place by the formation of granulation tissue, which becomes converted into connective tissue, and is covered over by epithelium growing in from the edges.

Those ulcers which are *stationary*—that is, neither healing nor spreading—may be in one of several conditions.

The Weak Condition.—Any ulcer may get into a weak state from receiving a blood-supply which is defective either in quantity or in quality. The granulations are small and smooth, and of a pale yellow or grey colour, the discharge is small in amount, and consists of thin serum and a few pus cells, and as this dries on the edges it forms scabs which interfere with the growth of epithelium.

Should the part become œdematous, either from general

causes, such as heart or kidney disease, or from local causes, such as varicose veins, the granulations share in the œdema, and there is an abundant serous discharge.

The excessive use of moist dressings leads to a third variety of weak ulcer—namely, one in which the granulations become large, soft, pale, and flabby, projecting beyond the level of the skin and overlapping the edges, which become pale and sodden. The term “proud flesh” is popularly applied to such redundant granulations.

The Callous Condition.—This condition is usually met with in ulcers on the lower third of the leg, and is often associated with the presence of varicose veins. It is chiefly met with in hospital practice. The want of healing is mainly due to impeded venous return and to œdema and induration of the surrounding skin and cellular tissues. The induration results from coagulation and partial organisation of the inflammatory effusion, and prevents the necessary contraction of the sore. The base of a callous ulcer lies at some distance below the level of the swollen, thickened, and white edges, and presents a glazed appearance, such granulations as are present being unhealthy and irregular. The discharge is usually watery, and cakes in the dressing. When from neglect and want of cleanliness the ulcer becomes inflamed, there is considerable pain, and the discharge is purulent and often offensive.

The prolonged hyperæmia of the tissues in relation to a callous ulcer of the leg often leads to changes in the underlying bones. The periosteum is abnormally thick and vascular, the superficial layers of the bone become injected and porous, and the bones, as a whole, are thickened. In the macerated bone “the surface is covered with irregular, stalactite-like processes or foliaceous masses, which, to a certain extent, follow the line of attachment of the interosseous membrane and of the inter-muscular septa” (Cathcart) (Fig. 23). When the whole



FIG. 23. — Bones of Leg, showing changes due to Chronic Ulcer.

thickness of the soft tissues is destroyed by the ulcerative process, the area of bone that comes to form the base of the ulcer projects as a flat, porous node, which in its turn may be eroded. These changes have often been mistaken for disease originating in the bone.

The *irritable condition* is met with in ulcers which occur, as a rule, just above the external malleolus in women of neurotic temperament. They are small in size and have prominent granulations, and by the aid of a probe points of excessive tenderness may be discovered. These, Hilton believed, correspond to exposed nerve filaments.

Ulcers which are spreading may be met with in one of several conditions.

The Inflamed Condition.—Any ulcer may become acutely inflamed from the access of fresh organisms, aided by mechanical irritation from trauma, ill-fitting splints or bandages, or want of rest, or from chemical irritants such as strong antiseptics. The best clinical example of an inflamed ulcer is the venereal soft sore. The base of the ulcer becomes red and angry-looking, the granulations disappear, and a copious discharge of thin yellow pus, mixed with blood, escapes. Sloughs of granulation tissue or of connective tissue may form. The edges become red, ragged, and everted, and the ulcer increases in size by spreading into the inflamed and œdematous surrounding tissues. Such ulcers are frequently multiple. Pain is a constant symptom, and is often severe, and there is usually some constitutional disturbance.

The *phagedænic condition* is the result of an ulcer being infected with specially virulent bacteria. It often occurs in syphilitic ulcers, and rapidly leads to a widespread destruction of tissue. It is also met with in the throat in some cases of scarlet fever, and may give rise to fatal hæmorrhage by ulcerating into large blood-vessels. All the local and constitutional signs of a severe septic infection are present.

Treatment of Ulcers.—The treatment of ulcers is a matter of great practical importance. An ulcer is not only an immediate cause of suffering to the patient, crippling and incapacitating him for his work, but is a distinct and constant menace to his health: the prolonged discharge reduces his strength; the open sore is a possible source of infection by the organisms of suppuration, erysipelas, or other specific diseases; phlebitis, with formation of septic emboli, leading to pyæmia, is liable to occur; and in old persons it is not uncommon for ulcers of long standing to become the seat of

cancer. In addition, the offensive odour of many ulcers renders the patient a source of annoyance and discomfort to others.

The primary object of treatment in any ulcer is to bring it into the condition of a healing sore. When this has been effected, nature will do the rest, provided extraneous sources of irritation are excluded.

Steps must be taken to facilitate the venous return from the ulcerated part, and to ensure that a sufficient supply of fresh, healthy blood reaches it. The septic element must be eliminated by disinfecting the ulcer and its surroundings, and any other sources of irritation must be removed.

If the patient's health is below par, good nourishing food, tonics, and general hygienic treatment are indicated.

Management of a Healing Sore.—Perhaps the best dressing for a healing sore is a layer of Lister's perforated oiled-silk protective, which is made to cover the raw surface and the skin for about a quarter of an inch beyond the margins of the sore. Over this three or four thicknesses of sterilised gauze, wrung out of boracic lotion or sterilised water, are applied, and covered by a pad of absorbent wool. As far as possible the part should be kept at rest, and the position should be adjusted so as to favour the circulation in the affected area.

The dressing may be renewed every two or three days, and care must be taken to avoid any rough handling of the sore. Any discharge that lies on the surface should be removed by a gentle stream of lotion rather than by wiping. The area round the sore should be cleansed before the fresh dressing is applied.

In some cases, healing goes on more rapidly under a dressing of weak boracic ointment (one-quarter the strength of the pharmacopœial preparation).

Dusting powders and poultice dressings are best avoided in the treatment of healing sores.

Treatment of Special Varieties of Ulcers.—Before beginning to treat a given ulcer, two questions have to be answered—first, What are the causative conditions present? and second, In what condition do I find the ulcer?—in other words, In what particulars does it differ from a healthy healing sore?

If the cause is a local one, it must be removed; if a constitutional one, means must be taken to counteract it. This done, the condition of the ulcer must be so modified as to bring it into the state of a healing sore, after which it will be managed on the lines already laid down.

Treatment in relation to the Cause of the Ulcer.—*Traumatic Group.*—The *prophylaxis* of these ulcers consists in excluding bacteria, by cleansing crushed or bruised parts, and applying sterilised dressings and properly adjusted splints. If there is reason to fear that the disinfection has not been complete, a Bier's constricting bandage should be applied for some hours each day. These measures will often prevent a grossly injured portion of skin dying, and will ensure asepticity should it do so. In the event of the skin giving way, the same form of dressing should be continued till the slough has separated and a healthy granulating surface is formed. The protective dressing appropriate to a healing sore is then substituted. *Pressure sores* are treated on the same lines.

The treatment of *burns and scalds* will be described later.

In *ulcers of the leg due to interference with the venous return*, the primary indication is to elevate the limb in order to facilitate the flow of the blood in the veins, and so admit of fresh blood reaching the part. The limb may be placed on pillows, or the foot of the bed raised on blocks, so that the ulcer lies on a higher level than the heart. Should varicose veins be present, the question of operative treatment must be considered.

When an *imperfect nerve-supply* is the main factor underlying ulcer formation, prophylaxis is the chief consideration. In patients suffering from spinal injuries or diseases, cerebral paralysis, or affections of the peripheral nerves, all sources of irritation, such as ill-fitting splints, tight bandages, moist applications, and hot bottles, should be avoided. Any part liable to pressure, from the position of the patient or otherwise, must be carefully protected by pads of wool, air-cushions, or water-bags, and must be kept absolutely dry. The skin should be hardened by daily applications of methylated spirit.

Should an ulcer form in spite of these precautions, the mildest antiseptics must be employed for bathing and dressing it, and as far as possible all dressings should be dry.

The *perforating ulcer* of the foot calls for special treatment. To avoid pressure on the sole of the foot, the patient must be confined to bed. As the main local obstacle to healing is the down-growth of epithelium along the sides of the ulcer, this must be removed by the knife or sharp spoon. The base also should be excised, and any bone which may have become involved should be gouged away, so as to leave a healthy and vascular surface. The cavity thus formed is stuffed with iodo-

form gauze and encouraged to heal from the bottom. After the ulcer is healed, the patient should wear in his boot a thick felt sole with a hole cut out opposite the situation of the cicatrix. When a joint has been opened into, the difficulty of thoroughly getting rid of all unhealthy and infected granulations is so great that amputation may be advisable; but it is to be remembered that ulceration may recur in the stump if pressure is put upon it. The treatment of any nervous disease or glycosuria which may coexist is, of course, indicated.

Exposure of the plantar nerves by an incision behind the internal malleolus, and subjecting them to forcible stretching, has been employed by Chipault and others in the treatment of perforating ulcers of the foot.

The ulcer that forms in relation to callosities on the sole of the foot is treated by paring away all the thickened skin, after softening it with soda fomentations, removing the unhealthy granulations, and applying stimulating dressings.

Treatment of Ulcers due to Constitutional Causes.—When ulcers are associated with such diseases as tuberculosis, syphilis, diabetes, Bright's disease, scurvy, or gout, these must receive appropriate treatment.

The local treatment of the *tuberculous ulcer* calls for special mention. If the ulcer is of limited extent and situated on an exposed part of the body, the most satisfactory method is complete removal, by means of the knife, scissors, or sharp spoon, of the ulcerated surface and of all the infected area around it, so as to leave a healthy surface from which granulations may spring up. Should the raw surface left be likely to result in an unsightly scar or in cicatricial contraction, skin-grafting should be employed.

For extensive ulcers on the limbs, the chest wall, or on other covered parts, or when operative treatment is contra-indicated, the use of tuberculin and exposure to the Röntgen rays have proved beneficial. The induction of passive hyperæmia, by Bier's or by Klapp's apparatus, should also be used, either alone or supplementary to other measures.

No ulcerative process responds so readily to medicinal treatment as the *syphilitic ulcer* does to full doses of iodide of potassium and mercury, and the local application of black wash. When the ulceration has lasted for a long time, however, and is widespread and deep, the duration of treatment is materially shortened by a thorough scraping with the sharp spoon.

Treatment in relation to the Condition of the Ulcer.—

Ulcers in a Weak Condition.—If the weak condition of the ulcer is due to anæmia or kidney disease, these affections must first be treated. Locally, the imperfect granulations should be scraped away, and some stimulating agent applied to the raw surface to promote the growth of healthy granulations. For this purpose a dressing of boracic lint wrung out of red lotion (2 grains of sulphate of zinc, and 10 minims of compound tincture of lavender, to an ounce of water), and covered with a layer of gutta-percha tissue, is useful.

When the condition has resulted from the prolonged use of moist dressings, these must be stopped, the redundant granulations clipped away with scissors, the surface rubbed with silver nitrate or sulphate of copper (blue-stone), and dry dressings applied.

When the ulcer has assumed the characters of a healing sore, Thiersch grafts may be applied to hasten cicatrisation.

Ulcers in a callous condition call for treatment in three directions—(1) The septic element must be eliminated. When the ulcer is very foul, relays of charcoal poultices (three parts of linseed meal to one of charcoal), maintained for thirty-six to forty-eight hours, are useful as a preliminary step. The base of the ulcer and the thickened edges should then be freely scraped with a sharp spoon, and the resulting raw surface sponged over with undiluted carbolic acid, after which an antiseptic dressing is applied, and changed daily till healthy granulations appear. (2) The venous return must be facilitated by elevation of the limb and massage. (3) The induration of the surrounding parts must be got rid of before contraction of the sore is possible. For this purpose the free application of blisters, as first recommended by Syme, leaves little to be desired. Liquor epispasticus painted over the parts, or a large fly-blister (emplastrum cantharidis) applied all round the ulcer, speedily disperses the inflammatory products which cause the induration. The use of elastic pressure or of strapping, or the making of multiple incisions in the skin around the ulcer, fulfil the same object.

So soon as the ulcer assumes the characters of a healing sore, it should be covered with Thiersch skin-grafts, which furnish a much better cicatrix than that which forms when the ulcer is allowed to heal without such aid.

A more radical and very successful method of treatment consists in excising the whole ulcer and grafting the raw surface.

Ambulatory Treatment.—When the circumstances of the

patient forbid his lying up in bed, the healing of the ulcer will be much delayed. He should be instructed to take every possible opportunity of placing the limb in an elevated position; and must constantly wear a firm bandage of *elastic webbing*. This webbing is porous and admits of evaporation of the skin and wound secretions—an advantage it has over Martin's rubber bandage. The bandage should extend from the toes to well above the knee, and should always be applied while the patient is in the recumbent position with the leg elevated, preferably before getting out of bed in the morning. Additional support is given to the veins if the bandage is applied as a figure-of-eight.

We have found the following method satisfactory in out-patient practice. The patient lying on a couch, the limb is raised about eighteen inches and kept in this position for five minutes—till the excess of blood has left it. With the limb still raised, the ulcer with the surrounding skin is covered with a layer, about half an inch thick, of finely powdered boracic acid, and the leg, from foot to knee, excluding the sole, is enveloped in a thick layer of wood-wool wadding. This is held in position by ordinary cotton bandages, painted over with liquid starch; while the starch is drying the limb is kept elevated. With this appliance the patient may continue to work, and the dressing does not require to be changed oftener than once in three or four weeks (W. G. Richardson).

When an ulcer becomes acutely *inflamed* as a result of superadded infection, antiseptic measures are employed to overcome the infection, and ichthyol or other soothing applications may be used to allay the pain.

The *phagedænic ulcer* calls for more energetic means of disinfection: the whole of the affected surface is touched with the actual cautery at a white heat, or is painted with pure carbolic acid. Relays of charcoal poultices are then applied, until the spread of the disease is arrested.

For the *irritable ulcer* the most satisfactory treatment is complete excision and subsequent skin-grafting.

SKIN-GRAFTING

The term skin-grafting is applied to certain procedures in which portions of epithelium or skin are applied to raw or granulating surfaces with a view to promoting the rapid formation of a cicatrix which is at once strong and pliable, and which does not subsequently tend to undergo contraction.

The grafts may be taken from the patient himself,—on the whole the most satisfactory source,—from another person, or from one of the lower animals.

The procedure is applicable to all forms of sores when in a healthy, healing condition, especially those resulting from burns, severe crushes, or septic processes involving wide destruction of skin. It may also be employed to cover in the raw surfaces left after the excision of new growths implicating the skin, or of patches of lupus. In rectifying such defects as extroversion of the bladder, ectropion of the eyelids, or destruction of the cheek or nose, skin-grafting is often of value.

It is of primary importance that the surface on which the grafts are placed should be aseptic and have a good vascular supply, and that the surrounding tissues be free of inflammation, œdema, or induration.

The best results are obtained when the grafts are placed on a fresh raw surface. A granulating surface is, on the whole, less satisfactory, because of the difficulty of ensuring its asepticity, and on account of the tendency of a cicatrix to undergo contraction.

In old-standing ulcers of the leg, it is best to excise the whole ulcer, including its edges and about a quarter to half an inch of the surrounding tissue, as well as the underlying fibrous tissue. In extensive ulcers resulting from recent burns, if the granulations are healthy and aseptic, the grafts may safely be placed on them directly. If, however, their asepticity cannot be relied upon, it is necessary to scrape away the superficial layer of the granulations, the young fibrous tissue underneath being conserved, as it is sufficiently vascular to nourish the grafts placed on it. There is no advantage in preserving any young epithelium which may have formed round the ulcer, as this is liable to break down after the grafts have united, leaving a raw ring round the newly formed cicatrix. The surface is bathed or sprayed with peroxide of hydrogen (10 volumes strength), and the oozing arrested by pressure with a pad of sterilised gauze, a layer of protective being placed next the wound to prevent the gauze adhering and starting the bleeding afresh when it is removed.

The skin from which the grafts are taken should be disinfected as for any other operation.

Methods of Grafting.—Several different procedures, which involve the transplantation of tangible portions of epithelium, are included under the term *epithelium-grafting*. Of these the methods of Thiersch and Reverdin are the most useful.

Thiersch's Method.—For all practical purposes, this is the procedure which yields the most satisfactory results and which is most generally applicable. It consists in transplanting strips of epidermis, shaved from the surface of the skin, the razor passing through the tips of the papillæ. The grafts are most conveniently obtained from the inner aspect of the thigh or upper arm, or from the front of the forearm, the skin in these regions being soft, pliable, and comparatively free from hairs. They are cut with a sharp hollow-ground razor, or Thiersch's skin-grafting knife, the blade of which is moistened with warm saline solution. The skin is stretched and kept flat and perfectly steady. To ensure uniform strips being cut, the razor must be kept parallel with the surface, and used with a short, rapid sawing movement. With a little practice grafts six or eight inches long by one or two inches broad can readily be cut.

The strips of epithelium thus obtained are directly transferred to the surface prepared for them, for which they should be made to form a complete carpet, slightly overlapping the edges of the sore and of one another. Firm pressure is then made with a pad of gauze over the grafts to express blood and air-bubbles, and to ensure accurate apposition.

When the grafts are applied to a fresh raw surface, and when there is no reason to anticipate any discharge, dry gauze or gauze smeared with sterilised vaseline is the most appropriate dressing. When the grafts are applied to a granulating surface, however, and when there may be doubt as to its perfect asepticity, perforated protective may be applied.

When it is feasible—for example, on the face or limbs of adults who will remain still during the after-treatment—we have found that it is best not to apply any dressing over the grafts, which are left freely exposed and only protected by a wire cage or shield such as is used after vaccination.

The surface from which the grafts have been taken is covered with a dry gauze dressing, or with a dressing of picric acid such as is used for superficial burns.

It is often difficult to decide when the dressing should be changed. In cases in which a dry dressing has been employed it may be left in position for from seven to ten days, by which time the grafts have united, and it may then be replaced by a dressing of weak boracic ointment or lanoline, to prevent the young epithelium from cracking and to keep the scar soft and pliable. When a protective dressing is used, it must be changed every third or fourth day until the grafts become fixed, after

which an ointment dressing is substituted. In all cases the utmost gentleness and care are necessary to avoid disturbance of the adhesions between the grafts and the surface to which they have been applied. Until the scar becomes consolidated, care must be taken to protect it from injury or irritation, and in the case of leg ulcers the patient should keep off his feet as much as possible and wear a supporting bandage.

The new skin is at first insensitive and is fixed to the underlying tissue, but in course of time new nerve fibres grow into it and sensation is restored, and the development of elastic tissue in the deeper part of the cicatrix renders it pliable and movable.

In *Reverdin's* method a portion of skin is raised with the point of a needle, and a piece about the size of a split pea removed with a razor or a pair of scissors curved on the flat. The graft, which consists of the epidermis and the superficial layers of the rete mucosum, is then cut into fragments not bigger than a pin-head, and these are planted over the surface. As each of these fragments has only a potential growth of about half an inch in diameter, it is advisable to place them so that the edges of the adjacent epithelial islets that form will touch one another, and to plant them near the edge of the ulcer, in order that the grafted epithelium may blend with that of the margin and so consolidate the cicatrix. Unless this is done, granulations grow up between the islets and often destroy them. The prepuce removed from a healthy child by circumcision may be used for Reverdin grafting.

The dressing, which consists of oiled-silk protective covered with pads of aseptic gauze and absorbent wool, is changed in four or five days. Many of the grafts disappear temporarily, but reappear in the course of a few days as thin bluish-white islands of epithelium, which gradually increase in size and thickness. The after-treatment is the same as for Thiersch grafts.

Grafts consisting of the *whole thickness of the true skin*, excluding the subcutaneous fat, are sometimes employed. When the grafts are taken from the human subject, they should be cut oval or spindle-shaped, to facilitate the approximation of the edges of the resulting wound. It is to be borne in mind that when separated from the body these portions of skin contract to about two-thirds of their original size, and this shrinkage must be allowed for. These grafts may be placed either on a fresh raw surface or on healthy granulations (Young). It is sometimes an advantage to stitch them in

position, especially on the face. The primary dressing and the subsequent treatment are the same as in Thiersch grafting. When successful, this method yields most satisfactory results.

Skin-grafting from the Lower Animals.—The best results have been obtained by planting the whole thickness of the skin of young warm-blooded animals, such as puppies, kittens, or rabbits, on a fresh raw surface. The animal is killed with chloroform, the anterior abdominal wall and flanks are shaved, and the skin, after being dissected up free of fat, is cut into pieces about two inches by one, and placed on the surface to be covered in. The after-treatment is the same as in Thiersch grafting. The hairs and skin glands are not reproduced.

Grafting of Mucous Membrane.—Successful attempts have been made to cover over defects in mucous membranes, such as the conjunctiva, the cheek, and the urethra, by grafts of mucous membrane taken from man or from the lower animals. The technique is similar to that employed in skin-grafting.

CHAPTER VII

GANGRENE

Definition—Clinical types: *Dry, Moist*—Clinical varieties—Gangrene primarily due to interference with the circulation: *Physico-chemical group; Embolic gangrene; Gangrene following ligation of arteries; Senile gangrene, atheroma; Diabetic gangrene; Gangrene from angiosclerosis; Gangrene from ergot; Raynaud's disease; Gangrene after acute fevers*—Gangrene primarily due to bacterial infection: *Acute traumatic gangrene; Malignant edema; Cancrum oris; Phagedena*—Bed-sores.

THE term gangrene is used to indicate the process by which a portion of tissue dies *en masse*, as distinguished from the molecular or cellular death which constitutes ulceration. The dead portion is known as a *slough*.

Gangrene may occur in any tissue of the body, and portions of limbs, of intestine, of lung, penis, or even of brain tissue, may die *en masse* and be thrown off as sloughs.

In this chapter we shall confine our attention to the process as it affects the limbs and superficial parts of the body, leaving gangrene of the viscera to be described in regional surgery.

CLINICAL TYPES OF GANGRENE

Two distinct types of gangrene are met with clinically, which, from their most obvious point of difference, are known as *dry* and *moist gangrene* respectively.

We shall have to study each of these types in detail; but, speaking generally, it may be said that dry gangrene is essentially due to a simple *interference with the blood-supply* of a part; while an essential factor in the production of moist gangrene is *bacterial infection*.

Several clinical varieties of each type are met with, but before describing these we shall first study the fundamental distinctions between the two types.

Dry Gangrene or Mummification is a comparatively slow

form of local death resulting, as a rule, from a diminution in the arterial blood-supply of the affected part, due to such causes as the gradual diminution of the lumen of the arteries by atheroma, or the blocking of the main vessel by an embolus. The fluids in the tissues are lost by evaporation, and the part becomes dry and shrivelled.

As the skin is usually intact, bacterial infection does not take place, or if it does, the want of moisture in the part renders it an unsuitable soil, and the organisms do not readily find a footing. Thus the effects of sepsis are absent, and any spread of the process that may take place is chiefly influenced by the anatomical distribution of the blocked arteries, and is arrested as soon as it reaches an area rich in anastomotic vessels. The throwing off of the dead portion is brought about by the formation of what is known as the *line of demarcation*: the irritation resulting from the contact of the dead with the still living tissue causes hyperæmia with dilatation of the blood-vessels, and infiltration with leucocytes on the proximal side of the junction. Granulations soon sprout from the living tissue, and by slowly eating into the dead portion produce a furrow, which gradually deepens until the complete separation of the slough is effected. As the muscles and bones have a richer blood supply than the skin, the death of skin and subcutaneous tissues extends higher than that of muscles and bone, with the result that the stump left after spontaneous separation is conical, the end of the bone projecting beyond the soft parts.

Clinical Features.—The part undergoing mortification becomes colder than normal, the temperature falling to that of the surrounding atmosphere. In many instances, but not in all, the onset of the process is accompanied by severe neuralgic pain in the part, probably due to anæmia of the nerves, to neuritis, or to the irritation of the exposed axis cylinders by the dead and dying tissues around them. This pain soon ceases and gives place to a complete loss of sensation. The dead part becomes dry, horny, shrivelled, and semi-transparent—at first of a dark-brown, but finally of a black colour, from the dissemination of blood pigment throughout the tissues. There is no putrefaction, and therefore no disagreeable odour; and the condition being non-infective, there is not necessarily any constitutional disturbance. In itself, therefore, dry gangrene does not involve immediate risk to the life of the patient. The danger lies in the fact that the raw surface at the line of demarcation furnishes a possible means of entrance for bacteria, which may lead to septic complications.

Moist Gangrene is an acute process, the dead part retaining its fluids, and so affording a favourable soil for the development of putrefactive or pyogenic bacteria. The action of the organisms, their toxins, and the inflammatory exudates on the adjacent tissues, leads to a rapid and wide spread of the process. The formation of a sulphide of iron by decomposition of the blood pigment gives to the tissues a greenish-black colour. The putrefactive gases evolved cause the tissues to become emphysematous and crepitant. The skin becomes moist and macerated, and bullæ, containing dark-coloured fluid or gases, form under the epidermis. There is an offensive putrid odour. Under certain conditions the dead part may undergo changes resembling more closely those of ordinary post-mortem decomposition. Owing to its nature the spread of the gangrene is seldom arrested by the natural protective processes, but usually continues, and the condition proves fatal from the absorption of toxins into the circulation.

The *clinical features* vary in the different varieties of moist gangrene, but in all the local results of bacterial action, and the usual constitutional disturbance associated with septic intoxication are present. The prognosis in moist gangrene is always grave in the extreme.

From what has been said, it will be gathered that in dry gangrene there is no urgent call for operation to save the patient's life, the primary indication being to prevent the access of bacteria to the dead part, and especially to the raw surface exposed in the line of demarcation. In moist gangrene, on the contrary, organisms having already obtained a footing, immediate removal of the dead and dying tissues, as a rule, offers the only hope of saving life.

CLINICAL VARIETIES OF GANGRENE

The different forms which gangrene assumes clinically are so varied that it is difficult to devise a simple classification. For practical purposes, however, they may be divided into two great classes: I. Those in which the gangrene is essentially due to *interference with the circulation*; and II. Those in which it is essentially due to *bacterial infection*.

Gangrene essentially due to Interference with the Circulation.—While the varieties of gangrene included in this group depend primarily on interference with the circulation, it is to be borne in mind that the clinical course of the

affection may be profoundly influenced by superadded infection with micro-organisms. Although the bacteria do not play the most important part in producing tissue necrosis, their subsequent introduction is an accident of such importance that it may change the whole aspect of affairs and convert a dry form of gangrene into one of the moist type. Moreover, the low state of vitality of the tissues, and the extreme difficulty of securing and maintaining asepsis, make it a sequel of great frequency.

Gangrene from Physico-chemical Causes.—When a localised portion of tissue—for example a piece of skin—is so severely crushed or bruised that its blood-vessels are occluded and its structure destroyed, it immediately dies, and, if not infected with bacteria, dries up and forms a shrivelled brown slough, which is slowly separated by the growth of granulation tissue beneath and around it.

Fingers, toes, or even considerable portions of limbs may in the same way be suddenly destroyed by severe trauma, and undergo mummification. If organisms gain access, typical moist gangrene may ensue, or changes similar to those of ordinary post-mortem decomposition may take place.

Severe *burns* and *scalds* may be followed by the same results. So long as the parts are kept absolutely dry—as, for example, by the picric acid method of treatment—the grossly damaged portions of tissue undergo dry gangrene; but when wet or oily dressings are applied and organisms gain access, moist gangrene follows.

Gangrene from Frost-bite.—It is difficult to draw the line between the third degree of chilblain and the milder forms of true frost-bite; the difference is merely one of degree. Frost-bite affects chiefly the toes and fingers,—especially the great toe and the little finger,—the ears, and the nose. In this country it is seldom seen except in members of the tramp class, who, in addition to being exposed to cold by sleeping in the open air, are ill fed and generally debilitated. The condition usually manifests itself after the parts, having been subjected to extreme cold, are brought into warm surroundings. The first symptom is numbness in the part, followed by a sense of weight, tingling, and finally by complete loss of sensation. The part attacked becomes white and bleached-looking, feels icy cold, and is insensitive to touch. Either immediately, or, it may be, not for several days, it becomes discoloured and swollen, and finally contracts and shrivels. Above the dead area the limb may be the seat of excruciating pain. The dead portion

is cast off, as in other forms of dry gangrene, by the formation of a line of demarcation.

Prophylaxis.—The first essential in the prophylaxis of gangrene from frost-bite is to avoid the too sudden application of heat. The patient should be placed in a cold room, and the part rubbed with snow, or put in a cold bath, and have light friction applied to it. As the circulation is restored the general surroundings and the local applications are gradually made warmer. Elevation of the part, wrapping it in cotton wool, and removal to a warmer room, are then permissible, and stimulants and warm drinks may be given with caution. When by these means the onset of gangrene is averted, recovery ensues, its onset being indicated by the white parts assuming a livid red hue and becoming the seat of an acute burning sensation.

Strong *chemical agents*, such as caustic potash, nitric or sulphuric acid, may also induce local tissue necrosis, the general appearances of the lesions produced being very like those of severe burns. The resulting sloughs are very slow to separate, and leave deep punched-out cavities which are long of healing.

Carbolic acid, even in comparatively weak solution, is liable to induce dry gangrene when applied as a fomentation to a finger, especially in women and children (Fig. 24). Thrombosis occurs in the blood-vessels of the part, which at first is pale and soft, but later becomes dark and leathery. On account of the anæsthetic action of carbolic acid, the onset of the process is painless, and the patient does not realise his danger. A line of demarcation soon forms, but the dead part separates very slowly.

Gangrene from Mechanical Constriction of the Vessels of the part.—The application of a bandage or plaster-of-Paris case too tightly, or of a tourniquet for too long a time, has been known to lead to death of the part beyond; but such cases are rare, as are also those due to the pressure of a fractured bone or of a tumour on a large artery or vein. When gangrene occurs from such causes, it tends to be of the moist type. Much commoner is it to meet with localised areas of necrosis due to the excessive pressure of splints over bony prominences, such as the external malleolus, the internal condyle of the humerus or femur, or over the dorsum of the foot. This is especially liable to occur when the nutrition of the skin is depressed by any interference with its nerve-supply, such as follows injuries to the spine or peripheral nerves, diseases of the brain, or

acute anterior poliomyelitis. On removing the splint the part pressed upon is found to be of a pale yellow or grey colour, and is surrounded by a ring of hyperæmic or congested skin. If purified and protected from septic infection, the clinical course is that of dry gangrene.

Closely allied to this is the *bed-sore*, in which necrosis of the skin and soft parts takes place. Bed-sores will be described at the end of this chapter.

Treatment.—The first indication in the treatment of the above varieties of gangrene is the exclusion of bacteria by thorough purification of the damaged part and its surroundings, and the application of dry, non-irritating antiseptic dressings.



FIG. 24.—Carbolic Gangrene. Girl æt. 22. Carbolic compress (1 in 60) applied overnight. Finger gangrenous in the morning.

When these measures are successful, dry gangrene ensues. The raw surface left after the separation of a slough of the skin may be allowed to heal by granulation, or may be covered by Thiersch skin-grafts. In the case of fingers or limbs it is not necessary to wait until spontaneous separation takes place, as this is often a very slow and tedious process. When a well-marked line of demarcation has formed, amputation may be performed just sufficiently far above it to enable suitable flaps to be made.

The ends of stumps, after spontaneous separation of the gangrenous portion, require to be trimmed, sufficient bone being removed to permit of the soft parts coming together.

If moist gangrene supervenes, amputation must be performed without delay, and at a higher level.

Embolie Gangrene (Fig. 25).—When the main artery of a part is *suddenly* occluded, whether by the impaction of an embolus or the formation of a thrombus in its lumen, unless the collateral circulation is sufficiently free to maintain the vitality of the tissues, gangrene results.

There is sudden pain at the site of impaction of the embolus, and the pulses beyond are lost. The limb becomes cold, numb, insensitive, and powerless. It is often pale at first—hence the term “white gangrene” sometimes applied to the early appearances, which closely resemble those presented by the limb of a corpse.



FIG. 25.—Embolie Gangrene of Hand and Forearm.

(From a photograph lent by Sir George T. Beatson.)

If the part is aseptic it becomes shrivelled, and presents the ordinary features of dry gangrene. It is very liable, however, especially in the lower extremity and where the veins also are obstructed, to become infected and to assume the characters of the moist type.

The *abdominal aorta* may become suddenly occluded at its bifurcation by an embolus, the obstruction of the iliacs and femorals inducing symmetrical gangrene of both extremities as high as Poupart's ligament. When gangrene follows occlusion of the *external iliac*, or of the *common femoral artery*, the death of the limb extends as high as the middle or upper third of the thigh. When the *superficial femoral or popliteal artery* is obstructed, the veins remaining pervious, the anastomosis

through the profunda is sufficient to maintain the vascular supply, and gangrene does not necessarily follow. The rupture of a popliteal aneurysm, however, by compressing the vein and the articular vessels, usually determines gangrene. When an embolus becomes impacted at the *bifurcation of the popliteal*, if gangrene ensues it usually spreads well up the leg.

When the *axillary artery* is the seat of embolic impaction, and gangrene ensues, the process usually reaches the middle of the upper arm. Gangrene following blocking of the *brachial* at its bifurcation usually extends as far as the junction of the middle and lower thirds of the forearm (Fig. 25).

Treatment.—The general treatment of embolic gangrene is the same as that for the senile form, which will be described below. It has been suggested to open the artery and remove the embolus. When amputation is indicated, it must be performed sufficiently high to ensure a free vascular supply to the flaps.

Gangrene following Ligation of Arteries.—After the ligation of an artery in its continuity—for example, in the treatment of aneurysm—the limb may for some days remain in a condition verging on gangrene, the distal parts being cold, devoid of sensation, and powerless. As the collateral circulation is established, the vitality of the tissues is gradually restored and these symptoms pass off. In some cases, however,—and especially in the lower extremity,—gangrene ensues and presents the same characters as that resulting from embolism. It tends to be of the dry type. The risk of gangrene is generally believed to be increased if the vein is occluded as well as the artery. In the light of cases we have observed, in which both artery and vein were ligated without gangrene supervening, we are inclined to believe that undue importance has been attached to this factor.

Senile Gangrene.—Senile gangrene is the commonest example of local death, produced by a *gradual* diminution in the quantity of arterial blood passing through the parts, as a result of atheroma or other chronic disease of the vessels leading to diminution of their calibre. It is the most typical example of the dry type of gangrene. As the term indicates, it occurs in old persons; but the patient's age is to be reckoned by the condition of his arteries rather than by the number of his years. Thus the vessels of a comparatively young man who has suffered from syphilis and been addicted to alcohol are more liable to atheromatous degeneration leading to this

form of gangrene than are those of a much older man who has lived a regular and abstemious life. This form of gangrene is much more common in men than in women. While it usually attacks only one foot, it is not uncommon for the other foot to be affected after an interval, and in some cases it is bilateral from the outset. It must clearly be understood that any form

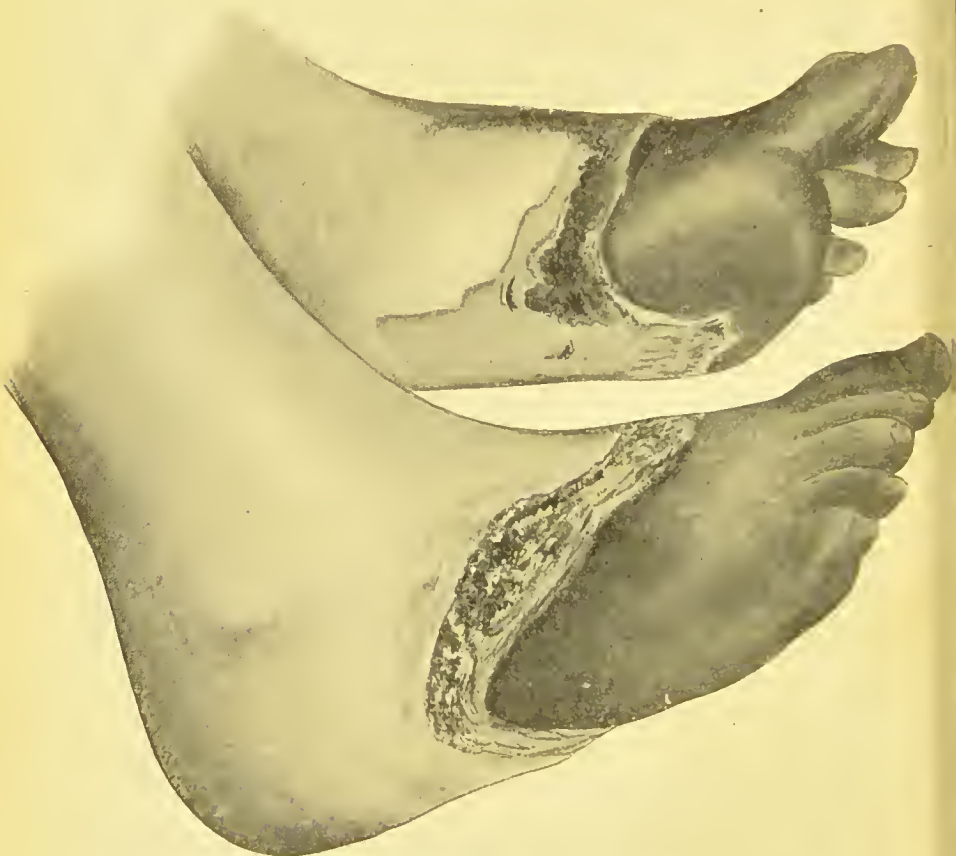


FIG. 26.—Senile Gangrene of both Feet, showing line of demarcation.

of gangrene may occur in old persons, the term senile being here restricted to that variety which results from atheroma.

Clinical Features.—The commonest seat of the disease is in the toes, especially the great toe, whence it spreads up the foot to the heel, or even to the leg. Although not necessarily traumatic in origin, there is often a history of some slight injury preceding its onset. The vitality of the tissues is so low that the balance between life and death may be turned by

the most trivial injury, such as a cut while paring a toe-nail or a corn, a blister caused by an ill-fitting shoe or the contact of a hot-bottle. In some cases the actual gangrene is determined by thrombosis of the popliteal or tibial arteries, which are already narrowed by atheroma.

It is common to find that the patient has been troubled for a long time before the onset of definite signs of gangrene, with cold feet, with tingling and loss of feeling, or a peculiar sensation as if walking on cotton wool.

The first evidence of the death of the part varies in different cases. Sometimes a dark-blue spot appears on the inner side of the great toe and gradually increases in size; or a blister containing blood-stained fluid may form. Streaks or patches of dark-blue mottling appear higher up on the foot or leg. In other cases a small sore surrounded by a congested areola forms in relation to the nail and refuses to heal. Such sores in old persons are always to be looked upon with suspicion and treated with the greatest care; and the urine should be examined for sugar. There is often severe, deep-seated pain of a neuralgic character, with cramps in the limb, and these may persist long after a line of demarcation has formed, or even after the slough has separated. The dying part loses sensibility to touch and becomes cold and shrivelled.

All the physical appearances and clinical symptoms associated with dry gangrene supervene, and the dead portion is delimited by a line of demarcation. If this forms slowly and irregularly it indicates a very unsatisfactory condition of the circulation; while, if it forms quickly and decidedly, the presumption is that the circulation in the parts above is fairly good. The separation of the dead part is always attended with the risk of septic infection taking place, and should this occur, the temperature rises and other evidences of septic absorption appear.

Prophylaxis.—The toes and feet of old people, the condition of whose circulation predisposes them to gangrene, should be specially protected from slight injuries such as may be received while paring nails, cutting corns, or wearing ill-fitting boots. The patient should also be warned of the risk of exposure to cold, the use of hot-bottles, and of placing the feet near a strong fire.

Treatment.—When there is evidence that gangrene has begun, the first indication is to prevent septic infection by thoroughly purifying the part, and after careful drying to wrap it in a thick layer of absorbent and antiseptic wool, retained in

place by a loosely applied bandage. A slight degree of elevation of the limb is an advantage, but it must not be sufficient to diminish the amount of blood entering the part. Hot-bottles are to be used with the utmost caution. As absolute dryness is essential, all ointments or other oily or greasy dressings are to be avoided, as they tend to prevent evaporation from the skin surface. Opium should be given freely to alleviate pain. Excessive stimulation is to be avoided, and the patient should be carefully dieted.

When gangrene is threatened, but has not actually taken place, it may sometimes be averted by establishing an anastomosis between the main artery of supply and its accompanying vein, so that the comparatively wide and dilatable vein is utilised to convey arterial blood to the imperfectly nourished area—*arterio-venous anastomosis* or *reversal of the circulation*. The femoral vessels, for example, are exposed at the apex of Scarpa's triangle or in Hunter's canal, and after being individually secured between clamps, are cut across. The distal end of the artery and the proximal end of the vein having been ligated, the proximal end of the artery and the distal end of the vein are united by end-to-end suture.

When the gangrene is limited to the toes in old and feeble patients, some surgeons advocate the expectant method of treatment, waiting for a line of demarcation to form and allowing the dead part to be separated. This takes place so slowly, however, that it necessitates the patient being laid up for many weeks, or even months; and we agree with the majority in advising early amputation.

In this connection it is worthy of note that there are certain points at which gangrene naturally tends to become arrested—namely, at the highly vascular areas in the neighbourhood of joints. Thus gangrene of the great toe often stops when it reaches the metatarso-phalangeal joint; or if it trespasses this limit it may be arrested either at the tarso-metatarsal or at the ankle joint. If these be passed, it usually spreads up the leg to just below the knee before signs of arrestment appear. Further, it is seen from pathological specimens that the spread is greater on the dorsal than on the plantar aspect, and that the death of skin and subcutaneous tissues extends higher than that of bone and muscle.

These facts furnish us with valuable indications as to the seat and method of amputation. Experience has proved that in senile gangrene of the lower extremity the most reliable and satisfactory results are obtained by amputating in the

region of the knee, care being taken to perform the operation so as to leave the prepatellar anastomosis intact by retaining the patella in the anterior flap. The operations we have found most satisfactory in these cases are: disarticulation at the knee by means of a circular incision carried round the limb, about three inches below the tubercle of the tibia, the joint being fully extended (A. G. Miller); and Gritti's supra-condylar amputation. Hæmorrhage is easily controlled by digital pressure, and the use of a tourniquet should be dispensed with, as the constriction of the limb is liable to interfere with the vitality of the flaps.

When the tibial vessels can be felt pulsating at the ankle it may be justifiable, if the patient urgently desires it, to amputate lower than the knee; but there is considerable risk of gangrene recurring in the stump and necessitating a second operation.

That amputation for senile gangrene performed between the ankle and the knee seldom succeeds, is explained by the fact that the vascular obstruction is usually in the upper part of the posterior tibial artery, and the operation is therefore performed through tissues with an inadequate blood-supply. It is not uncommon, indeed, on amputating above the knee, to find even the popliteal artery plugged by a clot. This should be removed by squeezing the vessel from above downward by a "milking" movement, or by "catheterising the artery" with the aid of a cannula with a terminal aperture.

It is to be borne in mind that the object in amputating in these cases is merely to remove the gangrenous part, and so to relieve the patient of the discomfort and the risks from sepsis which its presence involves. While it is true that, in spite of the feeble condition of many of these patients, the operation is borne remarkably well, provided it is done early and before the patient is worn out by pain and want of sleep, it is necessary to bear in mind that those who suffer from senile gangrene are of necessity bad lives, and a guarded opinion should be expressed as to the period during which the patient will survive the operation. The risk of the disease developing in the other limb has already been referred to.

Diabetic Gangrene.—This form of gangrene is prone to occur in persons over fifty years of age who suffer from diabetes mellitus. The vessels of these patients are often markedly atheromatous. In some cases the existence of the diabetes is unsuspected before the onset of the gangrene, and it is only on examining the urine that the cause of the condition is

discovered (Fig. 27). The gangrenous process seldom begins as suddenly as that associated with embolism, and, like senile gangrene, which it may closely simulate in its early stages, it not infrequently begins after a slight injury to one of the toes. It but rarely, however, assumes the dry, shrivelling type, as a rule being attended with swelling, œdema, and dusky redness of the foot, and severe pain. According to Sir James Paget, the dead part remains warm longer than in other forms of senile gangrene; there is a greater tendency for patches of skin at some distance from the primary seat of disease to become gangrenous, and for the death of tissue to extend upwards in the subcutaneous planes, leaving the overlying skin unaffected.



FIG. 27.—Diabetic Gangrene.
Glycosuria unsuspected till
gangrene developed.

The low vitality of the tissues favours the growth of bacteria, and if these gain access, the gangrene assumes the characters of the moist type and spreads rapidly. There is usually a peculiarly offensive odour about the patient, which differs from that of other forms of moist gangrene.

The rules for amputation are the same as those governing the treatment of senile gangrene, the level at which the limb is removed depending upon whether the gangrene is of the dry or moist type. The general treatment for diabetes must, of course, be employed whether amputation is performed or not.

Paget recommended that the dietetic treatment should not be so rigid as in uncomplicated diabetes, and that opium should be given freely.

The *prognosis* even after amputation is usually unfavourable. In many cases the patient dies with symptoms of diabetic coma within a few days of the operation; or, if he survives the operation, he may eventually succumb to the diabetes. In others there is sloughing of the flaps and death results from toxæmia. Occasionally the other limb becomes gangrenous. On the other hand, the glycosuria may be diminished or may even disappear after amputation.

Angio-sclerotic Gangrene.—A form of gangrene is occasionally met with in robust young persons, even in children, due to *angio-sclerosis*, with narrowing and thrombosis of the main

arteries as well as of the smaller veins. It usually occurs in the feet, is exceedingly painful, and runs a slow, tedious course; it generally calls for amputation.

Gangrene from Ergot.—Gangrene may occur from interference with blood-supply, the result of tetanic contraction of the minute vessels, such as results in ill-nourished persons who eat large quantities of coarse rye bread contaminated with the *claviceps purpurea* and containing the ergot of rye. It has also occurred in the fingers of patients who have taken ergot medicinally over long periods. The gangrene, which attacks the toes, fingers, ears, or nose, is preceded by formication, numbness, and pains in the parts to be affected, and is of the dry variety.

In this country it is usually met with in sailors off foreign ships, whose dietary largely consists of rye bread. Trivial injuries may be the starting-point, the anæsthesia produced by the ergotin preventing the patient taking notice of them. Alcoholism is a potent predisposing cause.

As it is impossible to predict how far the process will spread, it is advisable to wait for the formation of a line of demarcation before operating, and then to amputate immediately above the disease.

Raynaud's Disease, or Symmetrical Gangrene, is supposed to be due to spasm of the arterioles, resulting from peripheral neuritis. It occurs oftenest in women, between the ages of eighteen and thirty, who are the subjects of uterine disorders, anæmia, or chlorosis. Cold may be a predisposing factor, as the disease is commonest during the winter months. The digits of both hands or the toes of both feet are simultaneously attacked, and the disease seldom spreads beyond the phalanges or deeper than the skin.

The first evidence is that the fingers become cold, white, insensitive to touch and pain. These attacks of *local syncope* recur at varying intervals for months or even years. They last for a few minutes or even for some hours, and as they pass off the parts become hyperæmic and painful.

A more advanced stage of the disease is known as *local asphyria*. The circulation through the fingers becomes exceedingly sluggish, and the parts assume a dull, livid hue. There is swelling and burning or shooting pain. This may pass off in a few days, or may increase in severity, with the formation of bullæ, and end in dry gangrene. As a rule the slough which forms is comparatively small and superficial, but it may take some months to separate. The condition tends to recur in successive winters.

The *treatment* consists in remedying any nervous or uterine disorder that may be present, keeping the parts warm by wrapping them in cotton wool, and in the use of hot-air or electric baths, the parts being immersed in water through which a constant current is passed. When gangrene occurs, it is treated on the same lines as other forms of dry gangrene, but if amputation is called for it is only with a view to removing the dead part.

Gangrene occurring after Specific Infectious Diseases.—Gangrene is sometimes met with in patients recovering from typhus, typhoid, or other fevers, such as that associated with child-bed. It is due to thrombosis or embolism, and occurs in peripheral parts, such as the toes, fingers, nose, or ears.

Bacterial Varieties of Gangrene.

Gangrene primarily due to infection with bacteria is of the moist type, and tends to spread rapidly and to end fatally.

Acute Infective Gangrene usually follows trivial injuries, such as a pin-prick or a scratch. On the other hand, it may ensue very early on such severe injuries as result from railway, machinery, or street accidents, where, in addition to the extensive laceration and bruising of tissues, including vessels and nerves, there is gross dirt ground into the wounds. Some virulent pyogenic organism is introduced, and the highly poisonous toxins not only lead to serious constitutional disturbances, but by their local irritant action determine a rapidly spreading gangrenous process.

Clinical Features.—Often within a few hours of the injury the whole part rapidly becomes painful, swollen, œdematous, and tense. The skin is at first glazed, and perhaps paler than normal, but soon assumes a dull red or purplish hue, and bullæ form on the surface. Putrefactive gases may be evolved in the tissues, and their presence is indicated by emphysematous crackling when the part is handled. The spread of the disease is so rapid that its progress is quite visible from hour to hour, and may be traced by the occurrence of red lines along the course of the lymphatics of the limb.

In the most acute cases the death of the affected part takes place so rapidly that the local changes indicative of gangrene have not time to occur, and the fact that the part is dead may be overlooked.

Rigors may occur, but the temperature is not necessarily raised—indeed it is sometimes subnormal. The pulse is small,

feeble, rapid, and irregular. Unless promptly treated by amputation, death usually follows within thirty-six or forty-eight hours. Even early operation does not always avert the fatal issue, because the quantity of toxin absorbed and its extreme virulence are often more than even a robust subject can outlive.

Prophylaxis.—Every effort must be made to purify all such wounds as are contaminated by earth, street dust, stable refuse, or other forms of gross dirt. The scissors should be freely used to remove badly bruised or torn tissue, and no attempt should be made to close the wound by stitches. Rather should it be kept open with drainage-tubes or iodoform gauze or worsted inserted into its corners and crevices to ensure free drainage. As the organisms associated with this condition are mostly anaërobic, the use of peroxide of hydrogen is indicated for cleansing the wound.

Treatment.—When acute gangrene has set in no treatment short of amputation is of any avail, and the sooner this is done the greater is the hope of saving the patient. The limb must be amputated well beyond the apparent limits of the gangrenous area, and stringent precautions must be taken to avoid discharge from the already gangrenous area reaching the operation wound. An assistant or nurse, who is to take no other part in the operation, is told off to carry out this preliminary purification; to wrap the part to be removed in carbolised towels; and to hold the limb during the operation.

Malignant Œdema.—This form of acute spreading gangrene has been shown to be due to a specific organism, the *bacillus of malignant œdema*, which is found in garden soil, dung, and various putrefying animal substances. It is anaërobic, and occurs as long, thick rods with somewhat rounded ends and several laterally placed flagella. Spores, which have a very high power of resistance, form in the centre of the rods, and bulge out the sides so as to give the organisms a spindle-shaped outline. Other pathogenic organisms are often present and aid the specific bacillus in its action.

Clinical Features.—The disease has been defined as “a spreading inflammatory œdema attended with emphysema, and ultimately followed by gangrene of the skin and subjacent parts.” At the bedside it is difficult, if not impossible, to distinguish it from acute infective gangrene. Both follow on the same kinds of injury and run an exceedingly rapid course. In malignant œdema, however, the incidence of the disease is mainly on the superficial parts, which become livid, œdematous,

and emphysematous, and soon die. Bullæ form on the skin, and the tissues have "a peculiar heavy but not putrid odour." The general constitutional effects of the disease are extremely severe, and death may ensue within a few hours.

The *treatment* is the same as that of acute infective gangrene, and the prognosis is even less hopeful.

Cancrum Oris or Noma.—This disease is believed to be due to a specific bacillus, which occurs in long delicate rods, and is chiefly found at the margin of the gangrenous area. It is most prone to attack unhealthy children from two to five years of age, especially during their convalescence from such diseases

as measles, scarlet fever, or typhoid, but may attack adults when they are debilitated. It is most common in the mouth, but sometimes occurs on the vulva. In the mouth it begins as an ulcerative stomatitis, more especially affecting the gums or inner aspect of the cheek. The child lies prostrated, and from the open mouth foul-smelling saliva, streaked with blood, escapes; the face is of an ashy-grey colour, the lips dark and swollen. On the inner aspect of the cheek is a deeply ulcerated surface, with sloughy shreds of dark-



Fig. 28.—Cancrum oris.

(From a photograph lent by Sir George T. Beatson.)

brown or black tissue covering its base; the edges are irregular, firm, and swollen, and the surrounding mucous membrane is infiltrated and œdematous. In the course of a few hours a dark spot appears on the outer aspect of the cheek, and rapidly increases in size; towards the centre it is black, shading off through blue and grey into a dark-red area which extends over the cheek (Fig. 28). The tissue implicated is at first firm and indurated, but as it loses its vitality it becomes doughy and sodden. Finally a slough forms, perforating the cheek.

Meanwhile the process spreads inside the mouth, and the

gums, the floor of the mouth, or even the jaws, may become gangrenous and the teeth fall out. The constitutional disturbance is severe, the temperature raised, and the pulse feeble and rapid.

The extremely foetid odour which pervades the room or even the house the patient occupies, is usually sufficient to suggest the diagnosis of cancrum oris. The odour must not be mistaken for that due to decomposition of sordes on the teeth and gums of a debilitated patient.

The *prognosis* is always grave in the extreme, the main risks being general toxæmia and septic pneumonia. When recovery takes place there is serious deformity, and considerable portions of the jaws may be lost by necrosis.

Treatment.—The only satisfactory treatment is the thorough removal under an anæsthetic of all the sloughy tissue, with the surrounding zone in which the organisms are active. This is most efficiently accomplished by the knife or scissors, cutting until the tissue bleeds freely, after which the raw surface is painted with undiluted carbolic acid and dressed with iodoform gauze. It is often necessary to remove large pieces of bone when the necrotic process has implicated the jaws. The mouth must be constantly sprayed with peroxide of hydrogen, and washed out with a disinfectant and deodorant lotion, such as Condyl's fluid. The patient's general condition calls for free stimulation.

The deformity resulting from these necessarily heroic measures is often not so great as might be expected, and can be further diminished by plastic operations, which should be undertaken before cicatricial contraction has taken place.

Phagedæna, Hospital Gangrene, and Diphtheritic Gangrene.
—Fortunately, little need be said regarding these conditions. They are chiefly of historical interest as having constituted at one time the scourge of surgical wards, and as having been the first diseases to disappear after the introduction of antiseptic surgery.

BED-SORES

Bed-sores are most frequently met with in old and debilitated patients, or in those whose tissues are devitalised by acute or chronic diseases associated with stagnation of blood in the peripheral veins. Any interference with the nerve-supply of the skin, whether from injury or disease of the central nervous system or of the peripheral nerves, strongly predisposes to the

formation of bed-sores. Prolonged and excessive pressure over a bony prominence, especially if the parts be moist with skin secretions, urine, or wound discharges, determines the formation of a sore. Excoriations, which may develop into true bed-sores, sometimes form where two skin surfaces remain constantly apposed, as in the region of the scrotum or labium, under pendulous mammae, or between fingers or toes confined in a splint.

Clinical Features.—Two clinical varieties are met with—the acute and the chronic bed-sore.

The *acute* bed-sore usually occurs over the sacrum or buttock. It comes on very rapidly after spinal injuries and in the course of certain brain diseases. The part affected becomes red and congested, while the surrounding parts are œdematous and swollen, blisters form, and the skin loses its vitality.

In advanced cases of general paralysis of the insane, a peculiar form of acute bed-sore beginning as blisters, and passing on to the formation of black, dry eschars, which slowly separate, frequently occurs on such parts as the inner side of the knee, the angle of the scapula, and the heel.

The *chronic* bed-sore (Fig. 29) begins as a dusky reddish purple patch, which gradually becomes darker till it is almost black. The parts around are œdematous, and blisters may form. These burst and expose the papillæ of the skin, which are of a greenish hue. A tough greyish-black slough forms, and is slowly separated. It is not uncommon for the gangrenous area to continue to spread both in width and in depth till it reaches the periosteum or bone. Bed-sores over the sacrum sometimes implicate the spinal canal and lead to septic spinal meningitis, which usually proves fatal.

In old and debilitated patients the septic absorption taking place from a bed-sore often proves a serious complication of other surgical conditions. From this cause, for example, many old people succumb during the treatment of a fractured thigh.

The granulating surface left on the separation of the slough, under appropriate treatment, tends to heal comparatively rapidly.

Prevention of Bed-sores.—The first essential to the prevention of bed-sores is the regular changing of the patient's position, so that no one part of the body will be continuously pressed upon for any length of time. Ring-pads of wool, air-cushions, or water-beds are necessary to remove pressure from prominent

parts. Absolute dryness of the skin is all-important. At least once a day, the sacrum, buttocks, shoulder-blades, heels, elbows, malleoli, or other parts exposed to pressure, must be sponged with soap and water, thoroughly dried, and then rubbed with methylated spirit, which is allowed to dry on the skin. Dusting the part with boracic acid powder not only keeps it dry, but prevents the development of bacteria in the skin secretions.

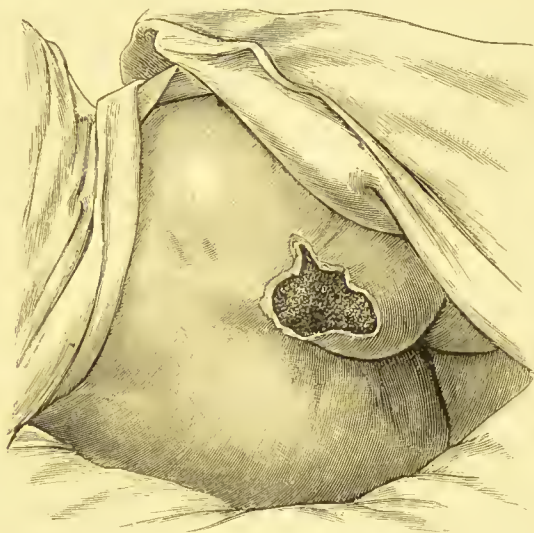


FIG. 29.—Pressure Bed-sore in an old woman with Fracture of Neck of Femur.

In operation cases, care must be taken that irritating chemicals used to purify the skin, such as turpentine, ether, or strong carbolic solutions, do not collect under the patient and remain in contact with the skin of the sacrum and buttocks during the time he is on the operating-table. There is reason to believe that the so-called "post-operation bed-sore" may be due to such causes. A similar result has been known to follow soiling of the sheets by the escape of a turpentine enema.

Treatment.—Once a bed-sore has formed, every effort must be made to prevent its spread. Mild antiseptic lotions are used to cleanse the broken surface, and dry absorbent dressings are applied and frequently changed. It is sometimes found necessary to employ moist or oily substances, such as boracic poultices, eucalyptus ointment, or balsam of Peru, to facilitate the separation of sloughs, or to promote the growth of granula-

tions. In patients who are not extremely debilitated the slough may be excised, the raw surface scraped, and then painted with undiluted carbolic acid.

Skin-grafting is sometimes useful in covering in the large raw surface left after separation or removal of sloughs.

CHAPTER VIII

BACTERIAL AND OTHER WOUND INFECTIONS

*Erysipelas—Diphtheria—Tetanus—Hydrophobia—Anthrax—Glanders—
Actinomycosis—Mycetoma—Delhi boil—Chigoe—Poisoning by insects
—Snake bites.*

ERYSIPELAS

ERYSIPELAS is an acute spreading infective disease of the skin or of a mucous membrane due to the action of a streptococcus. It is popularly known as "rose." The organism was at one time believed to be specific as regards this disease, and was called by Fehleisen the *streptococcus erysipelatis*, but it is now generally accepted that it is the ordinary streptococcus pyogenes "of a certain degree of virulence," although the conditions which so modify it that it causes erysipelas are as yet not fully understood. Infection invariably takes place through an abrasion of the surface, although this may be so slight that it escapes observation even when sought for. With our improved methods of wound treatment, erysipelas very rarely attacks an operation wound; when it does so it is usually in wounds about the face and mouth, where it is impossible to maintain asepsis. The streptococci are found most abundantly in the lymph spaces just beyond the swollen margin of the inflammatory area, and in the serous blebs which sometimes form on the surface, but they seldom invade the blood-stream.

Microscopically, four zones are to be recognised from without inwards in a patch of erysipelas. (1) Just beyond the red area is a zone in which active spread is taking place, all the lymphatic spaces being crowded with rapidly multiplying streptococci; (2) at the margin of the red area the lymph spaces are crowded with leucocytes, many of which have streptococci in their interior; (3) in a zone internal to this the inflammatory reaction is less marked, and all the free cocci have disappeared; and (4) towards the centre of the patch the tissues have

returned to the normal, no permanent structural change having taken place.

Clinical Features.—After an incubation period, which varies from fifteen to sixty hours, the patient complains of headache, pains in the back and limbs, loss of appetite, nausea, and very frequently there is vomiting. He has a chill or slight rigor, initiating a rise of temperature to 103°, 104°, or 105° F.; and a full bounding pulse of about 100 (Fig. 7). The tongue is foul, the breath heavy, and, as a rule, the bowels are constipated.

Around the seat of inoculation a diffuse red patch forms, varying in hue from a bright scarlet to a dull brick-red. The edges are slightly raised above the level of the surrounding skin, as may readily be recognised by gently stroking the part from the healthy towards the affected area. The skin is smooth, tense, and glossy, and presents here and there blisters filled with serous fluid. The local temperature is raised, and the part is the seat of a burning sensation and is tender to the touch, the most tender area being the actively spreading zone which lies about half an inch beyond the red margin.

The disease tends to spread spasmodically and irregularly, and the direction and extent of its progress may be recognised by mapping out the peripheral zone of tenderness. Red streaks appear along the lines of the superficial lymphatic vessels, and the deep lymphatics may sometimes be palpated as firm, tender cords. The neighbouring glands, also, are generally enlarged and tender.

The usual systemic symptoms associated with toxæmia are present — high temperature, gastro-intestinal disturbances, frequently albuminuria, and occasionally nocturnal delirium. A moderate degree of leucocytosis (15,000 to 20,000) is usually present in well-marked cases.

The disease lasts for from two or three days to as many weeks, and relapses are frequent. Spontaneous resolution usually takes place, but the disease may prove fatal from absorption of toxins, involvement of the brain or meninges, or from general streptococcal infection.

Clinical Varieties.—*Facial erysipelas* is the commonest clinical variety, infection usually occurring through some slight abrasion in the region of the mouth or nose. From this point of origin the inflammation may spread all over the face and scalp as far back as the nape of the neck. It stops, however, at the chin, and never extends on to the front of the neck. There is great œdema of the face, the eyes becoming

closed up, and the features unrecognisable. The inflammation may spread to the meninges, the intracranial venous sinuses, the eye, or the ear, and so add to the immediate risks, and lead to serious after-consequences. In some cases the erysipelas invades the mucous membrane of the mouth, and spreads to the fauces and larynx, setting up an œdema of the glottis which may prove fatal.

Erysipelas neonatorum occurs in the region of the umbilicus in young infants, and usually proves fatal.

In *puerperal women* the infection may occur in the genital tract, and give rise to a dangerous form of streptococcal infection.

Complications.—*Diffuse suppurative cellulitis* is the most serious local complication, and results from a mixed infection with other pyogenic bacteria. Small *localised superficial abscesses* may form during the convalescent stage. They are doubtless due to the action of skin bacteria, which attack the tissues devitalised by the erysipelas. A persistent form of *œdema* sometimes remains after recurrent attacks of erysipelas, especially when they affect the face or the lower extremity, a condition which is referred to with elephantiasis.

Treatment.—The first indication in treatment is to endeavour to arrest the spread of the process. We have found that by painting with linimentum iodi, a ring half an inch broad, about an inch in front of the peripheral tender zone—not the red margin—an artificial leucocytosis is produced, and the advancing streptococci are thereby arrested. Several coats of the iodine are applied, one after the other, and this is repeated daily for several days, even although the erysipelas has not overstepped the ring. Success depends upon using the liniment of iodine (the tincture is not strong enough), and in applying it well in front of the disease.

Scarification of the skin in front of the spreading margin acts in the same way, but is painful, and requires a general anæsthetic.

To allay the pain of erysipelas, perhaps the most useful local applications are ichthyol ointment (1 in 6), thiol (in 20 to 40 per cent. aqueous solution) painted on several times a day, or lead and opium fomentations.

The general treatment consists in attending to all the emunctories, in administering quinine in small—two-grain—doses every four hours, or salicylate of iron (2–5 gr. every three hours), and in giving plenty of fluid nourishment. It is worthy of note that the anti-streptococcic serum has proved of

less value in the treatment of erysipelas than might have been expected, probably because the serum is not made from the proper strain of streptococcus.

It is not necessary to isolate cases of erysipelas, provided the usual precautions against carrying infection from one patient to another are rigidly carried out.

DIPHTHERIA.

Diphtheria is an acute infective disease due to the action of a specific bacterium, the *bacillus diphtherie* or *Klebs-Löffler bacillus*.

The commonest site of infection is the fauces and soft palate, where at first the effects are local, and consist in the formation of a false membrane composed of necrosed epithelium, fibrin, leucocytes, and red blood corpuscles. As the disease progresses, a general toxin poisoning, associated with great muscular weakness, a tendency to syncope, and albuminuria, ensues. After the acute symptoms have passed off, various localised paralyses, affecting particularly the nerves of the palatal and orbital muscles, develop in from 15 to 20 per cent. of cases.

The disease is usually transmitted from one patient to another, but it may be contracted from cats, fowls, or through the milk of infected cows. Cases have occurred in which the surgeon has carried the infection from one patient to another through neglect of antiseptic precautions. The incubation period varies from two to seven days.

Clinical Features.—In *pharyngeal diphtheria*, on the first or second day of the disease, redness and swelling of the mucous membrane of the pharynx, tonsils, and palate are well marked, and small, circular greenish or grey patches of false membrane begin to appear. These rapidly increase in area and thickness, till they coalesce and form a complete covering to the parts. In the pharynx the false membrane is less adherent to the surface than it is when the disease affects the air-passages. The lymphatic glands behind the angle of the jaw enlarge and become tender, and may suppurate from superadded infection. There is pain on swallowing, and often earache; and the patient speaks with a nasal accent. He becomes weak and anæmic, and loses his appetite. There is often albuminuria. Leucocytosis is usually well marked before the injection of antitoxin; after the injection there is usually a diminution in the number

of leucocytes. The false membrane may separate and be cast off, after which the patient gradually recovers. Death may take place from gradual failure of the heart's action or from sudden syncope during some slight exertion.

Laryngeal diphtheria.—The disease may arise in the larynx, although, as a rule, it spreads thence from the pharynx. It first manifests itself by a short, dry, croupy cough, and hoarseness of the voice. The difficulty in breathing usually first takes place suddenly during the night, and once it begins, it rapidly gets worse. Inspiration becomes noisy, sometimes stridulous or metallic or sibilant, and there is marked indrawing of the epigastrium and lower intercostal spaces. The hoarseness becomes more marked, the cough more severe, and the patient very restless. The difficulty of breathing occurs in paroxysms, which gradually increase in frequency and severity, until at length the patient becomes asphyxiated and dies. The duration of the disease varies from a few hours to four or five days.

Diagnosis.—The finding of the Klebs-Löffler bacillus is the only conclusive evidence of the disease. The bacillus may be obtained by swabbing the throat with a piece of aseptic—not antiseptic—cotton wool or clean linen rag held in a pair of forceps, and rotated so as to entangle portions of the false membrane or exudate. The swab thus obtained is placed in a test-tube, previously sterilised by having had some water boiled in it, and sent to a laboratory for investigation. To identify the bacillus a piece of the membrane from the swab is rubbed on a cover glass, dried, and stained with methylene blue or other basic stain; or cultures may be made on agar or other suitable medium. When a bacteriological examination is impossible, or when the clinical features do not coincide with the results obtained, the patient should always be treated on the assumption that he suffers from diphtheria. So much doubt exists as to the real nature of membranous croup and its relationship to true diphtheria, that when the diagnosis between the two is uncertain, the safest plan is to treat the case as one of diphtheria.

Treatment.—An attempt may be made to destroy or to counteract the organisms by swabbing the throat with strong antiseptic solutions, such as 1 in 1000 corrosive sublimate or 1 in 30 carbolic acid, or by spraying with peroxide of hydrogen.

The antitoxic serum is our sheet-anchor in the treatment of diphtheria, and recourse should be had to its use as early as possible.

The initial dose should be a large one, certainly not less than 3000 units, and a further injection of 1500 units should be given in twelve hours if marked improvement does not take place. The earlier the injection, and the more concentrated the serum, the better are the results.

Within twenty-four hours of the injection the local symptoms usually begin to subside, and the membrane separates and is thrown off. At the same time the temperature falls, the pulse becomes slower, and the general condition of the patient improves. Beyond certain erythematous and urticarial rashes, and transient joint pains, which sometimes occur, no ill effects attend the use of the serum.

The general strength of the patient must be maintained by abundance of liquid food and stimulants.

Difficulty of swallowing may be met by the use of a stomach tube passed either through the mouth or nose. When this is impracticable, nutrient enemata are called for.

In laryngeal diphtheria, the interference with respiration may call for intubation of the larynx, or tracheotomy, but the antitoxin treatment has greatly diminished the number of cases in which it becomes necessary to have recourse to these measures.

Intubation consists in introducing through the mouth into the larynx a tube which allows the patient to breathe freely during the period while the membrane is becoming separated and thrown off. This is best done with the apparatus of O'Dwyer; but when this instrument is not available, a simple gum-elastic catheter with a terminal opening (as suggested by Macewen and Annandale) may be employed.

When intubation is impracticable, the operation of tracheotomy is called for if the patient's life is endangered by embarrassment of respiration.

In an epidemic of diphtheria, for example, in a public school, the throats of all those exposed to infection should be examined, and those who are found to be "carriers" of the bacillus should receive a prophylactic injection of antitoxic serum.

Diphtheria in other situations.—The diphtheritic process may spread from the pharynx to the nasal cavities, causing blocking of the nares, with a profuse ichorous discharge from the nostrils, and sometimes severe epistaxis. The inflammation may spread along the nasal duct to the conjunctiva. The middle ear also may become involved by spread along the Eustachian tube.

In children, diphtheria may occur on the vulva, vagina, prepuce, or glans penis, and give rise to difficulty in diagnosis, which is only cleared up by demonstration of the bacillus.

TETANUS.

Tetanus is a general disease resulting from the infection of a wound by a specific micro-organism, the *bacillus tetani*, and

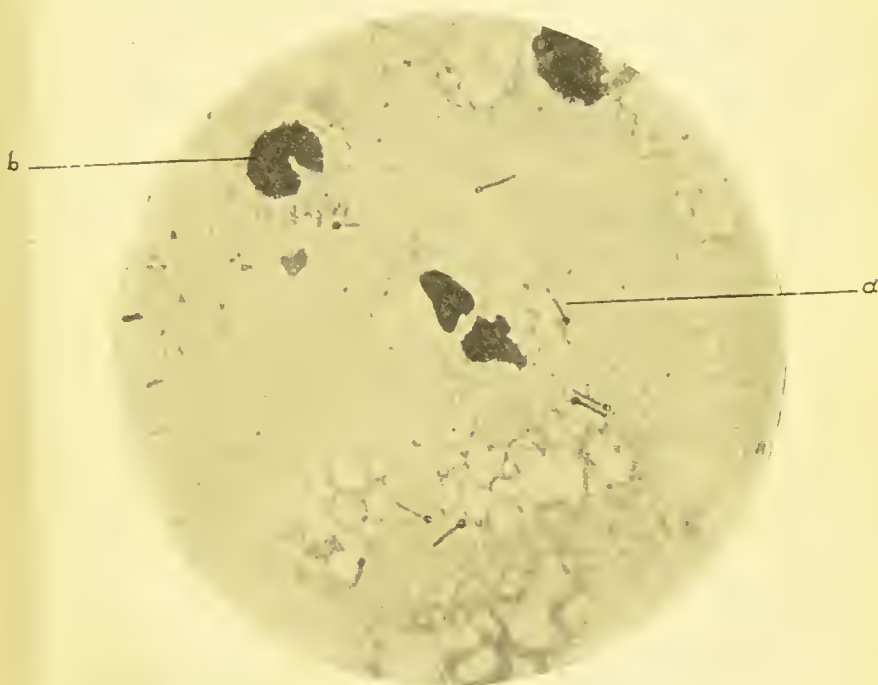


FIG. 30.—Bacillus of Tetanus from wound of infection. $\times 1000$ diam.

α = Bacillus with spore—drum-stick bacillus.

b = Leucocytes.

characterised by tonic contractions of one or more groups of muscles, with periodic exacerbations.

Etiology and Morbid Anatomy.—The tetanus bacillus is a slender rod-shaped organism. Each bacillus forms a single large spore, which is usually placed at one end and gives to the organism the shape of a drum-stick (Fig. 30). The spores are highly resistant to chemical agents, retain their vitality in a dry condition, and even survive boiling for five minutes.

The organism, which is a perfect anaërobe, is very widely distributed in nature, and is readily found in garden earth,

dung-heaps, and stable refuse. It can often be obtained also in the pus from the wound of infection in patients suffering from the disease, but it does not invade the body generally. Such wounds are usually unhealthy, and lined with necrotic tissue from which the special bacillus may be isolated, as well as other organisms—pyogenic or putrefactive—with which it is usually associated.

It is now believed that a broken surface, however small, is essential to the inoculation of the virus, and that no such thing as an “idiopathic” variety of tetanus exists.

It would appear, from experimental evidence, that the spores are the active agents in producing the disease, and that the presence of effused blood and some source of local irritation, such as a splinter of wood or other foreign body, favour their development. There is also reason to believe that the tetanus bacillus acts more certainly when introduced along with aerobic organisms, which, by using up the oxygen in the tissues, provide for it a suitable environment.

The toxin acts principally on the nerve centres in the spinal cord, to which it travels from the focus of infection by way of the motor nerve fibres. Its first effect on the motor ganglia of the cord is to render them hyper-sensitive, so that they are excited by mild stimuli, which under ordinary conditions would produce no reaction. As the toxin accumulates the reflex arc is affected, with the result that when a stimulus reaches the ganglia a motor discharge takes place, which spreads by ascending and descending collaterals to the reflex apparatus of the whole cord. As the toxin spreads it causes both motor hyper-tonus and hyper-excitability, which accounts for the tonic contraction and the clonic spasms characteristic of tetanus.

On post-mortem examination of patients who have died of tetanus, very few lesions are to be detected. The commonest are congestion of the central nervous system, notably the grey matter of the pons and medulla, and degenerative changes in the ganglion cells of the spinal cord.

Clinical Features.—The characteristic symptoms of tetanus do not, as a rule, appear earlier than the fourth or fifth day after the infliction of the wound, but the incubation period may extend to three weeks, and the wound may be quite healed before the disease declares itself. Usually, however, the wound is inflamed and suppurating, with ragged and sloughy edges. A slight feverish attack may mark the onset of the tetanic condition, or the patient may feel perfectly well until

the spasms begin. If careful observations be made, it may be found that the muscles in the immediate neighbourhood of the wound are the first to become contracted; but in the majority of instances the patient's first complaint is of pain and stiffness in the muscles of mastication, notably the masseter, so that he has difficulty in opening the mouth—hence the popular name “lock-jaw.” The other facial muscles soon share in the rigidity, and the face assumes a fixed, mask-like aspect. The angles of the mouth may be retracted, producing a grinning expression known as the *risus sardonius*.

The next muscles to become stiff and painful are those of the neck, especially the sterno-mastoid and trapezius. The patient is inclined to attribute the pain and stiffness to exposure to cold or rheumatism. At an early stage the diaphragm and the muscles of the anterior abdominal wall become contracted; later the muscles of the back and thorax are involved; and lastly those of the limbs. Although this is the typical order of involvement of the different groups of muscles, it is not always adhered to.

To this permanent tonic contraction of the muscles there are soon added clonic spasms. These spasms are at first slight and transient, with prolonged intervals between the attacks, but rapidly tend to become more frequent, more severe, and of longer duration, until eventually the patient simply passes out of one seizure into another.

The distribution of the spasms varies in different cases: in some it is confined to particular groups of muscles, such as those of the neck, back, abdominal walls, or limbs; in others all these groups are simultaneously involved.

When the muscles of the back become spasmodically contracted, the body is raised from the bed, sometimes to such an extent that the patient rests only on his heels and occiput—the position of *opisthotonos*. Lateral arching of the body from excessive action of the muscles on one side—*pleurosthotonos*—is not uncommon, the arching usually taking place towards the side on which the wound of infection exists. Less frequently the body is bent forward so that the knees and chin almost meet (*emprosthotonos*). Sometimes all the muscles simultaneously become rigid, so that the body assumes a statuesque attitude (*orthotonos*). When the thoracic muscles, including the diaphragm, are thrown into spasm, the patient experiences a distressing sensation as if he were gripped in a vice, and has extreme difficulty in getting breath. Between the attacks the

limbs are kept rigidly extended. The clonic spasms may be so severe as to rupture muscles or even to fracture one of the long bones.

As time goes on, the clonic exacerbations become more and more frequent, and the slightest external stimulus, such as the feeling of the pulse, a whisper in the room, a noise in the street, a draught of cold air, the effort to swallow, a question addressed to the patient or his attempt to answer, is sufficient to determine an attack. The movements are so forcible and so continuous that the nurse has great difficulty in keeping the bed-clothes on the patient, or even in keeping him in bed.

The general condition of the patient is pitiful in the extreme. He is fully conscious of the gravity of the disease, and his mind remains clear to the end. The suffering induced by the cramp-like spasms of the muscles keeps him in a constant state of fearful apprehension of the next seizure, and he is unable to sleep until he becomes utterly exhausted.

The temperature is moderately raised (100° to 102° F.), or may remain normal throughout. Shortly before death very high temperatures (110° F.) have been recorded, and it has been observed that the thermometer sometimes continues to rise after death, and may reach as high as 112° F. or more.

The pulse corresponds with the febrile condition. It is accelerated during the spasms, and may become exceedingly rapid and feeble before death, probably from paralysis of the vagus. Sudden death from cardiac paralysis or from cardiac spasm is not uncommon.

The respiration is affected in so far as the spasms of the respiratory muscles produce dyspnoea, and a feeling of impending suffocation which adds to the horrors of the disease.

One of the most constant symptoms is a copious perspiration, the patient being literally bathed in sweat. The urine is diminished in quantity, but as a rule is normal in composition; as in other acute infective conditions, albumen and blood may be present. Retention of urine may result from spasm of the urethral muscles, and necessitate the use of the catheter.

The fits may cease some time before death, or, on the other hand, death may occur during a paroxysm from fixation of the diaphragm and arrest of respiration.

Clinical Varieties of Tetanus. — *Acute or Fulminating Tetanus.* — This variety has been described above as the type of the disease. It is characterised by the shortness of the incubation period, the rapidity of its progress, the severity of

its symptoms, and its all but universally fatal issue in spite of treatment, death taking place in from one to four days.

Chronic Tetanus.—The difference between this and acute tetanus is mainly one of degree. Its incubation period is longer, it is more slow and insidious in its progress, and it never reaches the same degree of severity. Trismus is the most marked and constant form of spasm; and while the trunk muscles may be involved, those of respiration as a rule escape. Every additional day the patient lives adds to the probability of his ultimate recovery. When the disease does prove fatal, it is from exhaustion, and not from respiratory or cardiac spasm. The usual duration is from six to ten weeks.

Trismus.—This term is used to denote a form of tetanic spasm limited to the muscles of mastication. It is really a mild form of chronic tetanus, and the prognosis is favourable. It must not be confused with the fixation of the jaw sometimes associated with a wisdom-tooth gumboil, with tonsillitis, or with affections of the temporo-maxillary articulation.

Tetanus neonatorum is a form of tetanus occurring in infants of about a week old. Infection takes place through the umbilicus, and manifests itself clinically by spasms of the muscles of mastication. It is almost invariably fatal within a few days.

“*Head*” or “*Cephalic*” *Tetanus.*—This is a peculiar variety of traumatic tetanus which follows injuries to the head. It is characterised by the occurrence, on the same side as the head injury, of more or less complete paralysis of the facial muscles supplied by the seventh nerve, or of other muscles supplied by cranial nerves, particularly the oculo-motor. This paralysis of the cranial nerves is believed to be due to a selective action of one of the tetanus toxins on the nerve centre in the medulla, as well as a local action on the peripheral nerve-endings. There is usually well-marked trismus, and other tetanic symptoms, varying in severity, ultimately supervene. In head tetanus the muscles of deglutition are often specially involved—hence the name *tetanus hydrophobicus*. The disease is attended with a high mortality, particularly in cases in which paralysis is the first symptom to appear.

Differential Diagnosis.—There is little difficulty, as a rule, in diagnosing a case of fulminating tetanus, but there are several conditions with which it may occasionally be confused. In *strychnin poisoning*, for example, the spasms come on immediately after the patient has taken a toxic dose of the drug; they are tonic in character, but the muscles are relaxed

between the fits. If the dose is not lethal, the spasms soon cease. In *hydrophobia* a history of having been bitten by a rabid animal is usually forthcoming; the spasms, which are clonic in character, affect chiefly the muscles of respiration and deglutition, and pass off entirely in the intervals between attacks. Certain cases of *hæmorrhage into the lateral ventricles* of the brain also simulate tetanus, but an analysis of the symptoms will prevent errors in diagnosis. *Cerebro-spinal meningitis* and *basal meningitis* present certain superficial resemblances to tetanus, but there is no trismus, and the spasms chiefly affect the muscles of the neck and back. *Hysteria* and *catalepsy* may assume characters resembling those of tetanus, but there is little difficulty in distinguishing between these diseases. Lastly, in the *tetany* of children, or that following operations on the thyroid gland, the spasms are of a jerking character, affect chiefly the hands and fingers, and yield to medicinal treatment.

Prophylaxis.—The prevention of tetanus largely depends on thorough purification of all wounds that have been exposed to infection by earth, stable refuse, or street dust. There is evidence that prophylactic injections of anti-tetanic serum (10 c.c. introduced into the muscles of the buttock) are of value. All instruments and appliances used for operations on tetanic patients must be sterilised by *prolonged* boiling before being put away.

Treatment.—To arrest the formation and introduction into the circulation of further supplies of the toxin, the wound must be thoroughly purified, the unhealthy walls being bodily excised and the raw surface left sponged over with carbolic acid and dressed with iodoform gauze. Amputation is seldom called for to meet this indication.

To promote the excretion of toxins already absorbed, free action of the bowels, kidneys, and skin must be ensured. The introduction of saline solution into the veins, the rectum, or the cellular tissue may be had recourse to with this object.

The value of the *anti-tetanic serum* as a means of counteracting the toxins already in circulation is still in doubt. While it is true that a degree of immunity may be produced in animals by means of antitoxic serum, there is at present little evidence that any material benefit follows its use in fully developed, acute progressive tetanus in the human subject. The vast majority of the cases in which the serum has been employed and the patient has recovered have been of the chronic type of the disease, which naturally tends to spon-

taneous cure. In spite of these facts, however, and in view of the success which has followed the use of other sera, we are bound to give the patient the benefit of what is meanwhile the only rational treatment offering any hope of cure. The initial dose must be a large one—not less than 60 c.c., and several smaller doses may subsequently be given within the first twenty-four hours if the symptoms do not abate. The best results seem to have been obtained by Tizzoni's serum.

The serum should be injected directly into the nerve trunks leading from the focus of infection, as it is by this route that the toxins reach the spinal cord. It is necessary, however, that the serum be injected early and into a portion of the nerve not yet reached by the toxin, as it has been shown that the antitoxin has no neutralising effect on a toxin already absorbed by nerve tissue. By thus "blocking" the main afferent nerve trunks with antitoxin, the toxins are prevented from reaching the spinal cord. Clinical experience has shown, however, that benefit may follow the introduction of the serum directly into the cord. When the wound of infection is in the lower extremity, the serum is introduced into the lower part of the cord; when in the upper extremity, it should be injected in the cervical region. Antitetanic serum injected subcutaneously only neutralises the toxin circulating in the blood, and this is so small in quantity as to be practically negligible. Injection directly into the cranial cavity has been given up on account of the risks attending the procedure.

To conserve the patient's strength by preventing or diminishing the severity of the spasms, he should be placed in a quiet room, and every form of disturbance rigidly avoided. Sedatives must be given in large doses. Chloral is perhaps the best, and the patient should rarely have less than 150 grains in twenty-four hours. When he is unable to swallow, it should be given by the rectum. The administration of chloroform is of great value in conserving the strength of the patient, by abolishing the spasms, and enabling the attendants to administer nourishment or drugs either through a stomach tube or by the rectum. Extreme elevation of temperature is met by tepid sponging. It is necessary to use the catheter if retention of urine occurs.

HYDROPHOBIA

Hydrophobia is an acute infective disease following on the bite of a rabid animal. The analogies existing between hydrophobia and other diseases of undoubted bacterial origin justify the belief that this disease is due to a specific organism, although it has not yet been demonstrated.

In this country it most commonly follows the bite or lick of a rabid dog or cat. The virus appears to be communicated through the saliva of the animal, and to show a marked affinity for nerve tissues; and the disease is most likely to develop when the patient is infected on the face or other uncovered part, or in a part richly endowed with nerves.

Rabies in the Dog.—The animal becomes depressed and listless, develops a depraved appetite, eating all kinds of rubbish and filth; is peculiarly irritable and snappish towards other dogs; and when it moves about, takes no notice of surrounding objects. The bark becomes hoarse; a thick ropy mucus collects in the mouth, and the creature has difficulty in swallowing, although it makes violent attempts to lap water. Paralysis of the lower jaw and of the limbs precedes death, which usually takes place in five or six days. The wild fury which is generally supposed to characterise a mad dog is usually conspicuous by its absence.

A dog which has bitten a person should on no account be killed until its condition has been proved one way or the other. Should rabies develop and its destruction become necessary, the head and spinal cord should be retained and forwarded, packed in ice, to a competent observer. Much anxiety to the person bitten and to his friends would be avoided if these rules were observed, because in many cases it will be shown that the animal did not after all suffer from rabies, and that the patient consequently runs no risk. If, on the other hand, rabies is proved to be present, the patient should be submitted to the Pasteur treatment.

Clinical Features in Man.—There is almost always a history of the patient having been bitten or licked by an animal supposed to suffer from rabies. The incubation period averages about forty days, but varies from a fortnight to seven or eight months, and is shorter in young than in old persons. The original wound has long since healed, and beyond a slight itchiness or pain shooting along the nerves of the part, shows no sign of disturbance. A few days of general malaise, with chills and giddiness, precede the onset of the acute manifestations, which affect chiefly the muscles of deglutition and respiration. One of the earliest signs is that the patient has periodically a sudden catch in his breathing “resembling what often occurs when a person goes into a cold bath.” This is due to spasm of the diaphragm, and is frequently accompanied by a loud-sounding hicough, likened by the laity to the barking of a dog. Difficulty in swallowing fluids may be the first symptom.

The spasms rapidly spread to all the muscles of deglutition and respiration, so that the patient not only has the greatest difficulty in swallowing, but has a constant sense of impending suffocation. To add to his distress, a copious secretion of viscid saliva fills his mouth. Any voluntary effort, as well as all forms of external stimuli, only serve to aggravate the spasms which are always induced by the attempt to swallow fluid, or even by the sound of running water.

The temperature is raised; the pulse is small, rapid, and intermittent; and the urine may contain sugar and albumen.

The mind may remain clear to the end, or the patient may have delusions, supposing himself to be surrounded by terrifying forms. There is always extreme mental agitation and despair, and the sufferer is in constant fear of his impending fate. Happily the inevitable issue is not long delayed, death usually occurring in from two to four days from the onset. The symptoms of the disease are so characteristic that there is no difficulty in diagnosis. The only condition with which it is liable to be confused is the variety of cephalic tetanus in which the muscles of deglutition are specially involved—the so-called tetanus hydrophobicus.

Prophylaxis.—The bite of an animal suspected of being rabid should be cauterised at once by means of the actual or Paquelin cautery, or by a strong chemical escharotic such as pure carbolic acid, after which antiseptic dressings are applied.

It is, however, to Pasteur's *preventive inoculation* that we must look for our best hope of averting the onset of symptoms. "It may now be taken as established that a grave responsibility rests on those concerned if a person bitten by a mad animal is not subjected to the Pasteur treatment" (Muir and Ritchie).

This method is based on the fact that the long incubation period of the disease admits of the patient being inoculated with a modified virus producing a mild attack, which protects him from the natural disease—as in artificially developing immunity against a bacterial disease.

Treatment.—When the symptoms have once developed they can only be palliated. The patient must be kept absolutely quiet and free from all sources of irritation. The spasms may be diminished by means of chloral and bromides, or by chloroform inhalation. There is great difficulty in feeding the patient, and all nourishment and stimulants may require to be administered by the rectum.

ANTHRAX

Anthrax is a comparatively rare disease, communicable to man from certain of the lower animals, such as sheep, oxen, horses, deer, and other herbivora. In animals it is characterised by symptoms of acute general poisoning, and, from the fact that it produces a marked enlargement of the spleen, is known in veterinary surgery as "splenic fever."

The *bacillus anthracis* (Fig. 31), the largest of the known pathogenic bacteria, occurs in groups or in chains made up of numerous bacilli, each bacillus measuring from 6 to 8 μ in length.

The organisms are found in enormous numbers throughout the bodies of animals that have died of anthrax, and are readily recognised and cultivated.

Sporulation only takes place outside the body, probably because free oxygen is necessary to the process. In the spore-free condition, the organisms are readily destroyed by ordinary germicides, and by the gastric juice. The spores, on the other hand, have a high degree of resistance. Not only do they remain viable in the dry state for long periods, even up to a year, but they survive boiling for five minutes, and must be subjected to dry heat at 140° C. for several hours before they are destroyed.

Clinical Varieties of Anthrax.—In man, anthrax may manifest itself in one of three clinical forms.

It may be transmitted by means of spores or bacilli directly from a diseased animal to those who, by their occupation or

otherwise, are brought into contact with it—for example, shepherds, butchers, veterinary surgeons, or hide-porters. The path of infection is usually through an abrasion of the skin, and the primary manifestations are local, constituting what is known as *the malignant pustule*.

In other cases the disease is contracted through the inhalation of the dried spores into the respiratory passages. This occurs oftenest in those who work amongst wool, fur, and rags, and

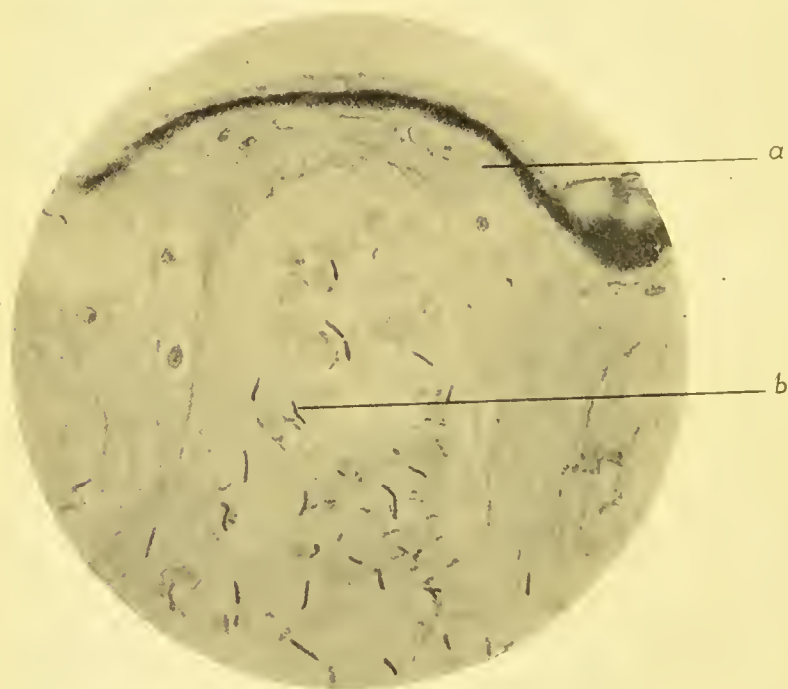


FIG. 31.—Bacillus of Anthrax from skin vesicle in case of malignant pustule. $\times 400$ diam.

a = Altered epithelium over small vesicle. *b* = Anthrax bacilli in vesicle.

a form of acute pneumonia of great virulence ensues. This affection is known as *wool-sorter's disease*, and is almost universally fatal.

There is reason to believe that infection may also take place by means of spores ingested into the alimentary canal in meat or milk derived from diseased animals, or in infected water. The symptoms which follow are those of an acute and severe gastro-intestinal affection, and the mesenteric glands become greatly enlarged.

Clinical Features of Malignant Pustule.—We shall here confine ourselves to the consideration of the local lesion as it occurs in the skin—the *malignant pustule*.

The point of infection is usually on an uncovered part of the body, such as the face, hands, arms, or back of the neck, and the wound may be exceedingly minute. After an incubation period varying from a few hours to three or four days, a small red nodule, surrounded by reddish-blue blisters containing clear or blood-stained fluid, appears at the seat of inoculation. This is accompanied by a sensation of burning and intense itchiness. The blister soon bursts and forms a black, dried slough, around which one or more rings of small blisters form. Outside this the skin becomes indurated and swollen, and a widespread œdema occurs. When the seat of inoculation is in the vicinity of the neck, this œdema may implicate the larynx and lead to dangerous interference with respiration. The neighbouring lymphatic glands soon become enlarged and tender.

The risk to the life of the patient in malignant pustule is that of the disease becoming generalised — *anthracæmia*. When this occurs it shows itself in the course of forty-eight to sixty hours in the form of fever, with a temperature of 102° to 104° F., severe pains in the limbs, diarrhœa, hæmaturia, and great weakness. The patient is usually remarkably free from anxiety and distress, even when dangerously ill, and dies in the course of from five to eight days with symptoms of general bacterial intoxication.

Morbid Anatomy of Malignant Pustule.—The central slough is composed of necrosed tissue and altered blood. The surrounding skin is intensely congested and œdematous, and the stratum corneum is raised as a blister from the rete Malpighii. The bacilli are found in the peripheral portion of the slough, in the blisters, and in the adjacent lymphatics.

Differential Diagnosis.—The clinical features which have been described above serve to distinguish malignant pustule from an ordinary boil or carbuncle, and from the other acute infective conditions with which it is liable to be confused. In doubtful cases a bacteriological examination should be made. Inquiry should also be made as to the possibility of the patient having been in contact with infected material either in the ordinary course of his occupation or in any other way.

Prognosis.—If left to itself the disease is frequently fatal. The mortality is greatest when the disease attacks the face or neck, and least when the lower extremity is affected.

Prophylaxis.—Any wound suspected of being infected by the anthrax bacillus should at once be cauterised with the actual cautery, or sponged over with pure carbolic acid.

Treatment.—The best results hitherto obtained have followed the use of the serum introduced by Sclavo, which appears to act by inducing a defensive phagocytosis, rather than by neutralising toxins. The initial dose is 40 c.c., and if the serum is given early in the disease, the beneficial effects are manifest in a few hours. When the serum treatment is not available, injections of nucleinate of soda (phagocytin) may be employed (p. 22).

The experience of some observers seems to indicate that the results obtained by leaving the pustule to nature and merely protecting it with an antiseptic dressing are as good as those following excision of the affected area which was formerly practised.

The general treatment consists in feeding and stimulating the patient as freely as possible. Quinine, in 5 to 10 grain doses every four hours, and powdered ipecacuanha, in 40 to 60 grain doses every four hours, have also been employed with apparent benefit.

GLANDERS

Glanders is due to the action of a specific bacterium, the *bacillus mallei*, which resembles the tubercle bacillus, save that it is somewhat shorter and broader, and does not stain by Gram's method. It requires higher temperatures for its cultivation than the tubercle bacillus, and its growth on potato is of a characteristic chocolate-brown colour, with a greenish-yellow ring at the margin of the growth. The bacillus mallei retains its vitality for long periods under ordinary conditions, but is readily killed by heat and chemical agents. It does not form spores.

Clinical Features.—Both in the lower animals and in man the bacillus gives rise to two distinct types of disease—*acute glanders*, and *chronic glanders* or *farcy*.

Acute Glanders is most commonly met with in the horse and in other equine animals, horned cattle being immune. It affects the septum of the nose and adjacent parts, firm, translucent, greyish nodules containing lymphoid and epithelioid cells appearing in the mucous membrane. These nodules subsequently break down in the centre, forming irregular ulcers, which are attended with profuse discharge, and marked inflammatory swelling. The cervical lymphatic glands, as well

as the lungs, spleen, and liver, may be the seat of secondary nodules.

In man, acute glanders is commoner than the chronic variety. Infection always takes place through an abraded surface, and usually on one of the uncovered parts of the body—most commonly the skin of the hands, arms, or face; or on the mucous membrane of the mouth, nose, or eye. The disease has been acquired by accidental inoculation in the course of experimental investigations in the laboratory, and proved fatal. The incubation period is from three to five days.

The *local* manifestations are pain and swelling in the region of the infected wound, with inflammatory redness around it and along the lines of the superficial lymphatics. In the course of a week, small, firm nodules appear, and are rapidly transformed into pustules. These may occur on the face and in the vicinity of joints, and may be mistaken for the eruption of small-pox.

After breaking down, these pustules give rise to irregular ulcers, which by their confluence lead to extensive destruction of skin. Sometimes the nasal mucous membrane becomes affected, and produces a discharge—at first watery, but later sanious and purulent. Necrosis of the bones of the nose may take place, in which case the discharge becomes peculiarly offensive. In nearly every case metastatic abscesses form in different parts of the body, such as the lungs, joints, or muscles.

During the development of the disease the patient feels ill, complains of headache and pains in the limbs, the temperature rises to 104° or even to 106° F., and assumes a pyæmic type. The pulse becomes rapid and weak. The tongue is dry and brown. There is profuse sweating, albuminuria, and often insomnia with delirium. Death may take place within a week, but more frequently occurs during the second or third week.

Differential Diagnosis.—There is nothing characteristic in the site of the primary lesion in man, and the condition may, during the early stages, be mistaken for a boil or carbuncle, or for any acute inflammatory condition. Later, the disease may simulate acute articular rheumatism, or may manifest all the symptoms of acute septicæmia or pyæmia. The diagnosis is established by the recognition of the bacillus. Veterinary surgeons attach great importance to the mallein test as a means of diagnosis in animals, but in the human subject its

use is attended with considerable risk and is not to be recommended.

Treatment.—Excision of the primary nodule, followed by cauterisation with a red-hot iron and sponging with pure carbolic acid, should be carried out, provided the condition is sufficiently limited to render complete removal practicable.

When secondary abscesses form in accessible situations, they must be incised, scraped, disinfected, and drained. The general treatment is carried out on the same lines as in other acute infective diseases.

Chronic Glanders.—*In the horse* the chronic form of glanders is known as *farcy*, and follows infection through an abrasion of the skin, involving chiefly the superficial lymphatic vessels and glands. The lymphatics become indurated and nodular, constituting what veterinarians call *farcy pipes* and *farcy buds*.

In man also the clinical features of the chronic variety of the disease are somewhat different from those of the acute form. Here, too, infection takes place through a broken cutaneous surface, and leads to a superficial lymphangitis with nodular thickening of the lymphatics (*farcy buds*). The neighbouring glands soon become swollen and indurated. The primary lesion meanwhile inflames, suppurates, and, after breaking down, leaves a large, irregular ulcer with thickened edges and a foul, purulent or bloody discharge. The glands break down in the same way, and lead to wide destruction of skin, and the resulting sinuses and ulcers are exceedingly intractable. Secondary deposits in the subcutaneous tissue, the muscles, and other parts, are not uncommon, and the nasal mucous membrane may become involved. The disease often runs a chronic course, extending to four or five months, or even longer. Recovery takes place in about 50 per cent. of cases, but the convalescence is very prolonged, and at any time the disease may assume the characters of the acute variety and speedily prove fatal.

The *differential diagnosis* is often very difficult, especially in the chronic nodules, in which it may be impossible to demonstrate the bacillus. The ulcerated lesions of farcy have to be distinguished from those of tubercle, syphilis, and other forms of infective granuloma.

Treatment.—Limited areas of disease should be completely excised. The general condition of the patient must be improved by tonics, good food, and favourable hygienic surroundings. In some cases potassium iodide acts beneficially.

ACTINOMYCOSIS

Actinomycosis is a chronic disease due to the action of an organism somewhat higher in the vegetable scale than ordinary bacteria—the *streptothrix actinomyces* or *ray fungus*.

Etiology and Morbid Anatomy.—The actinomyces, which has never been met with outside the body, gives rise in oxen, horses, and other animals to tumour-like masses composed of

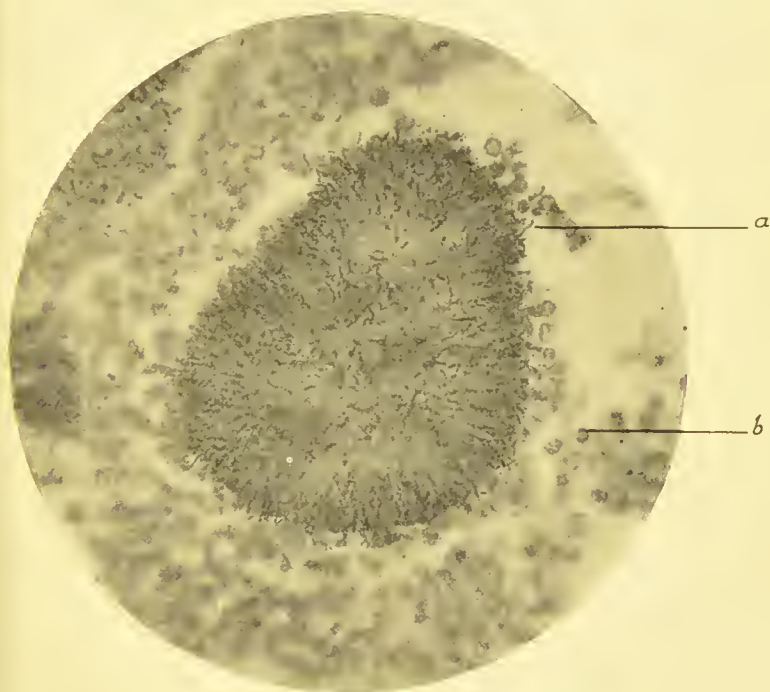


FIG. 32—Colony of Actinomyces. $\times 400$ diam.
a = Filaments of streptothrix actinomyces. b = Pus cells.

granulation tissue; and in man to chronic suppurative processes which may result in a condition resembling chronic pyæmia. The actinomyces is more complex in structure than other pathogenic organisms, and occurs in the tissues in the form of small, round, semi-translucent bodies, about the size of a pin-head or less, and consisting of colonies of the fungus. On account of their yellow tint they are spoken of as “sulphur grains.” Each colony is made up of a series of thin, interlacing, and branching *filaments*, some of which are broken up so as to form masses or chains of *cocci*; and around the

periphery of the colony are elongated, pear-shaped, hyaline, *club-like bodies* (Fig. 32).

Infection is believed to be conveyed by the husks of cereals, especially barley; and the organism has been found adhering to particles of grain embedded in the tissues of animals suffering from the disease. In human subjects there is often a history of exposure to infection from such sources, and the disease is said to be most common during the harvesting months.

Around each colony of actinomyces is a zone of granulation tissue in which suppuration usually occurs, so that the fungus comes to lie in a bath of greenish-yellow pus. As the process spreads these purulent foci become confluent and form abscess cavities. When metastasis takes place, as it occasionally does, the fungus is transmitted by the blood-vessels, as in pyæmia.

Clinical Features.—In man the disease may be met with in the skin, the organisms gaining access through an abrasion, and spreading by the formation of new nodules in the same way as tuberculosis.

The region of the mouth and jaws is one of the commonest sites of surgical actinomycosis. Infection takes place, as a rule, along the side of a carious tooth, and spreads to the lower jaw. A swelling is slowly and insidiously developed, but when the loose connective tissue of the neck becomes infiltrated, the spread is more rapid. The whole region becomes infiltrated and swollen, and the skin ultimately gives way and free suppuration occurs, resulting in the formation of sinuses. The characteristic greenish-grey or yellow granules are seen in the pus, and when examined microscopically reveal the colonies of actinomyces.

Less frequently the upper jaw becomes affected, and the disease may spread to the base of the skull and brain. The vertebræ may become involved by infection taking place through the pharynx or œsophagus, and leading to a condition simulating tuberculous disease of the spine. When it implicates the intestinal canal and its accessory glands, the lungs, pleura and bronchial tubes, or the brain, the disease is not amenable to surgical treatment.

Differential Diagnosis.—The conditions likely to be mistaken for surgical actinomycosis are sarcoma, tubercle, and syphilis. In the early stages the differential diagnosis is exceedingly difficult. In many cases it is only possible when suppuration has occurred and the fungus can be demonstrated.

The slow destruction of the affected tissue by suppuration,

the absence of pain, tenderness, and redness, simulate tuberculosis, but the absence of glandular involvement helps to distinguish it.

Syphilitic lesions are liable to be mistaken for actinomycosis, all the more that in both diseases improvement follows the administration of iodides. When it affects the lower jaw, in its early stages, actinomycosis may closely simulate a periosteal sarcoma.

The recognition of the fungus is the crucial point in diagnosis.

Prognosis.—Spontaneous cure rarely occurs. When the disease implicates internal organs, it is almost always fatal. On external parts the destructive process gradually spreads, and the patient eventually succumbs to superadded septic infection. When, from its situation, the primary focus admits of removal, the prognosis is more favourable.

Treatment.—The only surgical treatment is early and free removal of the affected tissues, after which the wound is cauterised by the actual cautery, and sponged over with pure carbolic acid. The cavity is packed with iodoform gauze, no attempt being made to close the wound.

Success has attended the use of a vaccine prepared from cultures of the organism; and the X-rays, combined with the administration of iodides in large doses, or with intra-muscular injections of a 10 per cent. solution of cacodylate of soda, have proved of benefit.

MYCETOMA, OR MADURA FOOT.—Mycetoma is a chronic disease due to an organism resembling that of actinomycosis, but not identical with it. It is endemic in certain tropical countries, and is most frequently met with in India. Infection takes place through an abrasion of the skin, and the disease usually occurs on the feet of adult males who work barefooted in the fields.

Clinical Features.—The disease begins on the foot as an indurated patch, which becomes discoloured and permeated by black or yellow nodules containing the organism. These nodules spread through the foot, break down by suppuration, and numerous minute abscesses lined by granulation tissues are thus formed. In the pus are found yellow particles likened to fish-roe, or black pigmented granules like gunpowder. Sinuses form, and the whole foot becomes greatly swollen and distorted by flattening of the sole and dorsiflexion of the toes. Areas of caries or necrosis occur in the bones of the foot, and the disease gradually extends up the leg. There is but little pain, and no glandular involvement or constitutional disturbance. The disease runs a prolonged course, sometimes lasting for twenty or thirty years. Spontaneous cure never takes place, and the risk to life is that of prolonged suppuration.

If the disease is localised, it may be removed by the knife or sharp

spoon, and the part afterwards cauterised. As a rule, amputation well above the disease is the best line of treatment. Unlike actinomycosis, this disease does not appear to be benefited by iodides.

DELHI BOIL.—*Synonyms*—Aleppo boil, Biskra button, *Furuncul**us orientalis*, Natal sore.

Delhi boil is a chronic inflammatory disease, most commonly met with in India, especially towards the end of the wet season. The disease occurs oftenest on the face, and is believed to be due to an organism, although this has not been demonstrated. The infection is supposed to be conveyed through water used for washing, or by the bites of insects.

Clinical Features.—A red spot, resembling the mark of a mosquito bite, appears on the affected part, and is attended with itching. After be-

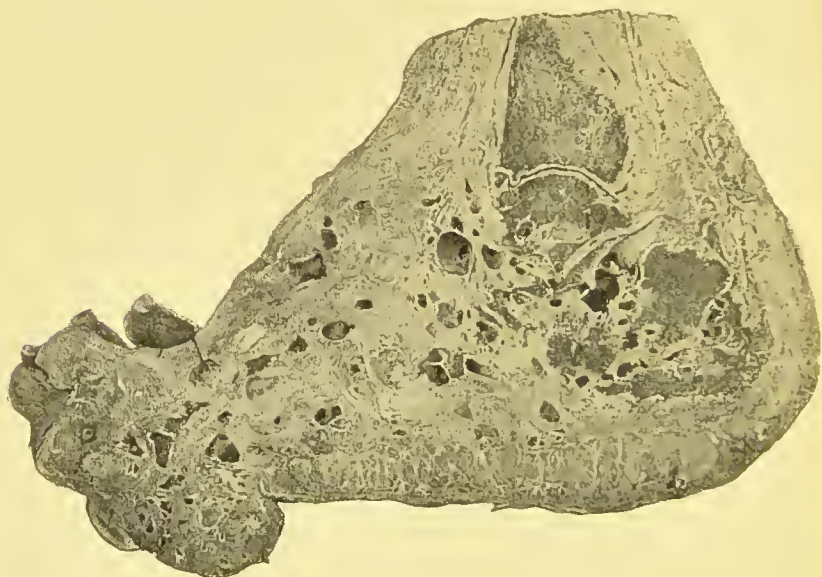


FIG. 33.—Mycetoma, or Madura Foot.

(Museum of Royal College of Surgeons, Edinburgh.)

coming papular and increasing to the size of a pea, desquamation takes place, leaving a dull-red surface, over which in the course of several weeks there develops a series of small yellowish-white spots, from which serum exudes, and, drying, forms a thick scab. Under this scab the skin ulcerates, leaving small oval sores with sharply bevelled edges, and an uneven floor covered with yellow or sanious pus. These sores vary in number from one to forty or fifty. They may last for months and then heal spontaneously, or may continue to spread until arrested by suitable treatment. There is no enlargement of adjacent glands, and but little inflammatory reaction in the surrounding tissues; nor is there any marked constitutional disturbance. Recovery is often followed by cicatricial contraction leading to deformity of the face.

The *treatment* consists in destroying the original papule by the actual

cautery, acid nitrate of mercury, or pure carbolic acid. The ulcers should be scraped with the sharp spoon, and cauterised.

CHIGOE.—Chigoe or jigger results from the introduction of the eggs of the sand-flea (*Pulex penetrans*) into the tissues. It occurs in tropical Africa, South America, and the West Indies. The impregnated female flea remains attached to the part till the eggs mature, when by their irritation they cause localised inflammation with pustules or vesicles on the surface. Children are most commonly attacked, particularly about the toe-nails and on the scrotum. The treatment consists in picking out the insect with a blunt needle, special care being taken not to break it up. The puncture is then cauterised. The application of essential oils to the feet acts as a preventive.

POISONING BY INSECTS.—The bites of certain insects, such as mosquitoes, midges, different varieties of flies, wasps, and spiders, may be followed by serious complications. The effects are mainly due to the injection of an irritant acid secretion, the exact nature of which has not been ascertained.

The local lesion is a puncture, surrounded by a zone of hyperæmia, wheals, or vesicles, and is associated with burning sensations and itching, which usually pass off in a few hours, but may recur at intervals, especially when the patient is warm in bed. Scratching also reproduces the local signs and symptoms. Where the connective tissue is loose—for example, in the eyelid or scrotum—there is often considerable swelling; and in the mouth and fauces this may lead to œdema of the glottis, which may prove fatal.

The *treatment* consists in the local application of dilute alkalis such as ammonia water, solutions of carbonate or bicarbonate of soda, or sal-volatile. Weak carbolic lotions, or lead and opium lotion, are useful in allaying the local irritation. One of the best means of neutralising the poison is to apply to the sting a drop of a mixture containing equal parts of pure carbolic acid and liquor ammoniæ.

Free stimulation is called for when severe constitutional symptoms are present.

SNAKE-BITES.—We are here only concerned with the injuries inflicted by the venomous varieties of snakes, the most important of which are the hooded snakes of India, the rattle-snakes of America, the horned snakes of Africa, the viper of Europe, and the adder of the United Kingdom.

While the virulence of these creatures varies widely, they are all capable of producing in a greater or less degree symptoms of acute poisoning in man and other animals. By means of two recurved fangs attached to the upper jaw, and connected by a duct with poison-secreting glands, they introduce into their prey a thick, transparent, yellowish fluid, of acid reaction, probably of the nature of an albumose, and known as the *venom*.

The *clinical features* resulting from the injection of the venom vary directly in intensity with the amount of the poison introduced, and the rapidity with which it reaches the circulating blood, being most marked when it immediately enters a large vein. The poison is innocuous when taken into the stomach.

Locally the snake inflicts a double wound, passing vertically into the subcutaneous tissue; the edges of the punctures are ecchymosed, and the adjacent vessels the seat of thrombosis. Immediately there is intense pain, and considerable swelling with congestion, which tends to spread towards the trunk. Extensive gangrene may ensue. There is no special involvement of the lymphatics.

The *general symptoms* may come on at once if the snake is a particularly venomous one, or not for some hours if less virulent. In the majority of viper or adder bites the constitutional disturbance is slight and transient, if it appears at all. Snake-bites in children are particularly dangerous.

The patient's condition is one of profound shock with faintness, giddiness, dimness of sight, and a feeling of great terror. The pupils dilate, the skin becomes moist with a clammy sweat, and nausea with vomiting, sometimes of blood, ensues. High fever, cramps, loss of sensation, hæmaturia, and melæna are among the other symptoms that may be present. The pulse becomes feeble and rapid, the respiratory nerve centres are profoundly depressed, and delirium followed by coma usually precedes the fatal issue, which may take place in from five to forty-eight hours. If the patient survives for two days the prognosis is favourable.

Treatment.—A broad ligature should be tied tightly round the limb above the seat of infection, to prevent the poison passing into the general circulation, and bleeding from the wound should be encouraged. The application of an elastic bandage from above downward to empty the blood out of the infected portion of the limb has been recommended. The whole of the bite should at once be excised, and crystals of permanganate of potash rubbed into the wound until it is black, or peroxide of hydrogen applied with the object of destroying the poison by oxidation.

The general treatment consists in free stimulation with whisky, brandy, ammonia, digitalis, etc. Hypodermic injections of strychnin in doses sufficiently large to produce a slight degree of poisoning by the drug are particularly useful. The most rational treatment, when it is available, is the use of the *antivenin* introduced by Fraser and Calmette.

CHAPTER IX

TUBERCULOSIS

Definition of tuberculous disease—Tubercle bacilli—Methods of infection—Inherited and acquired predisposition—Action of the bacillus upon the tissues—Tuberculous granulation tissue—Natural cure—Recrudescence of the disease—THE TUBERCULOUS ABSCESS—Contents and wall of the abscess—Tuberculous sinuses.

THE term tuberculosis is applied generically to the various pathological conditions which result from the action of the tubercle bacillus—the organism proved to be the cause of tubercle by Koch in 1882. The diseases produced by this organism are spoken of as *tuberculous*, and as this term indicates the essential nature of the affection, it is to be preferred to the terms “strumous” and “scrofulous” previously employed.

Tuberculosis may be met with in any of the tissues or organs of the body, but it occurs more frequently in some situations than in others. It is very common, for example, in lymphatic glands, in bones and joints, in the peritoneum, the intestine, the kidney, prostate and testis, and in the skin and subcutaneous cellular tissue. It is seldom met with in the breast or in muscles, and it rarely affects the ovary, the pancreas, the parotid, or the thyroid.

Tubercle bacilli occur as straight or slightly curved rods, measuring about $3\ \mu$ by $.3\ \mu$ (Fig. 34). They have no power of movement. It is as yet undecided whether or not they form spores. Their virulence varies widely, and they are more tenacious of life than the common pyogenic bacteria. In a dry state, for example, they can retain their vitality for months; and they can also survive immersion in water for prolonged periods. They resist the action of the products of putrefaction for a considerable time, and are not destroyed by digestive processes in the stomach and intestine. They may be killed in a few minutes by immersion in 1 in 20 carbolic lotion, by boiling, or by exposure to steam under pressure.

“The great multiplying ground of tubercle bacilli is the animal body, and tuberculous tissues and secretions containing the bacilli are the chief, if not the only means by which the disease is spread. The bacilli leave the body in large numbers in the sputum of phthisical patients, and when the sputum becomes dried and pulverised they are set free in the air. Their presence in the air of rooms inhabited by consumptive patients has been repeatedly demonstrated. So far as the

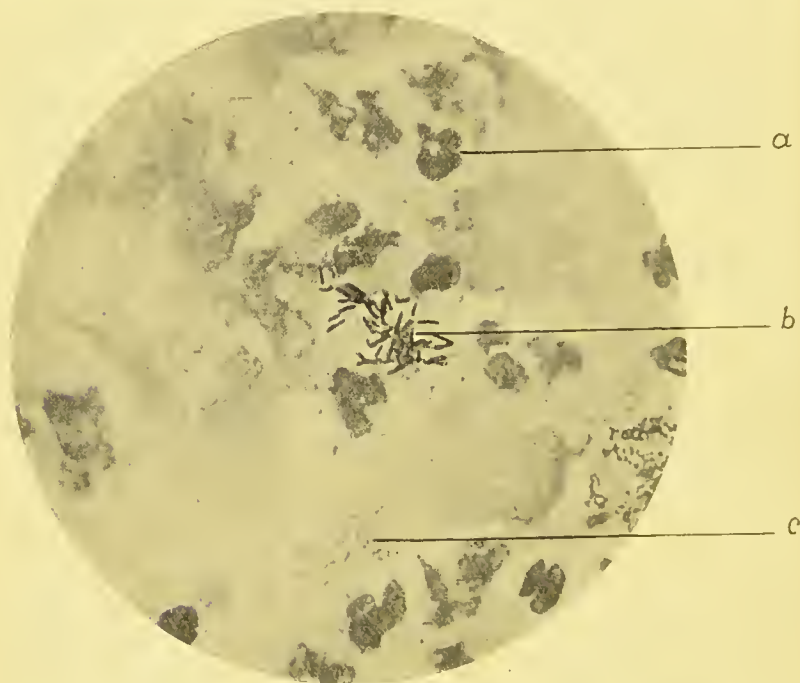


FIG. 34.—Tubercle bacilli in Pus from Urine in case of genito-urinary tuberculosis. $\times 1000$ diam.

a = Pus cell.

b = Clump of tubercle bacilli.

c = Small bacilli—probably *B. urea*.

human subject is concerned, the great means of disseminating the bacilli in the outer world is dried phthisical sputum. Another source of infection, especially in children, is the milk of cows affected with tuberculosis of the udder.”¹

In marked contrast to what obtains in the infective diseases which have already been described, tuberculosis rarely results from the infection of a wound on the surface of the body. In exceptional instances, however, this does occur, and in

¹ Muir and Ritchie, *Manual of Bacteriology*.

illustration of the fact may be cited the case of a servant girl who cut her finger with a broken spittoon containing the sputum of her consumptive master ; the wound subsequently showed evidence of tuberculous infection, which ultimately spread up along the lymphatic vessels of the arm. Pathologists, too, whose hands, unless they are protected by rubber gloves, are frequently exposed to the contact of tuberculous tissues and pus, are liable to suffer from a form of tuberculosis of the skin of the finger, known as *anatomical tubercle*. Slight wounds of the feet in children who go about barefoot in towns sometimes become infected with tubercle. Operation wounds made with instruments contaminated with tuberculous material have also been known to become infected. It is highly probable that the common form of tuberculosis of the skin known as "lupus" arises by direct infection from without.

In the vast majority of cases the tubercle bacillus gains entrance to the body by way of the mucous surfaces, the organisms being either inhaled or swallowed.

The respiratory mucous membrane, from the nose and mouth to the terminations of the air-tubes in the lungs, is constantly exposed to infection by the inhalation of air laden with dust and other minute particles to which the virus is adherent. Bacilli are especially apt to lodge about the pharynx and pass to the pharyngeal lymphoid tissue and tonsils, and by way of the lymphatic vessels to the glands. The glands most frequently infected in this way are the cervical glands, and those within the cavity of the chest—particularly the bronchial glands at the root of the lung.

The entrance of the bacilli into one or other of these groups of glands may result in active tuberculous disease of the infected group. On the other hand, there is reason to believe that the organisms may lie in a dormant or latent condition for an almost indefinite period, and only become active long afterwards, when some general depression of the patient's health produces conditions which favour their growth. When the organisms become active in this way, the tuberculous tissue undergoes softening and disintegration, and the infective material may erupt into an adjacent vein, and thus enter the general circulation, and be carried by the blood-stream to distant parts of the body, and so give rise either to a localised tuberculosis where they lodge, or to a general tuberculosis. The initial infection of the lymphatic glands within the chest, being unattended with any external or clinical evidence of its occurrence, remains unrecognised and unsuspected, and the

patient, usually a child, may present the appearances of even robust health. At any subsequent period, however, tuberculous disease may make its appearance in some tissue of the body—for example, in a bone or joint, in the kidney or testicle, or in the membranes of the brain. Many tuberculous patients are to be regarded as possessing in their bronchial glands, or elsewhere, an internal store of bacilli, to which the disease for which advice is sought owes its origin, and from which similar outbreaks of tuberculosis may originate in the future.

The alimentary mucous membrane, especially that of the lower ileum and cæcum, is exposed to infection by swallowed sputum and by food materials, such as milk, containing tubercle bacilli. The organisms may lodge in the mucous membrane and cause tuberculous ulceration, or they may be carried through the wall of the bowel into the lacteals, along which they pass to the mesenteric glands. There they may become arrested and give rise to tuberculous disease of the glands; or they may become active at a subsequent period, or lie dormant indefinitely. It may happen that the bacilli from a tuberculous mesenteric gland are carried by way of the receptacle of the chyle and the thoracic duct into the general circulation, and in this way infect distant parts of the body, or give rise to general tuberculosis. In some cases the transference of the infective material is more direct—for example, when a softened mesenteric gland erupts into a contiguous vein and so infects the circulating blood, or erupts on to the peritoneum covering the mesentery and sets up a tuberculous peritonitis.

Predisposition to Tuberculosis.—That some persons are more prone to become the subjects of tuberculosis than others, is evident from the fact that while under the existing conditions of civilised life all are exposed to the infection, only a comparatively small number acquire the disease. The precise conditions that favour the entrance, lodgment, and growth of the bacilli in those predisposed to the disease are somewhat uncertain. It may be that there is some peculiarity of the tissues which renders them a specially suitable soil for the organisms, or that the patient's power of resisting the invasion of the virus is abnormally low. In any case, with regard to the etiology of tuberculosis, this predisposition is to be looked upon as a factor second in importance only to the presence of the bacilli themselves. In some cases the predisposition is inherited, in others it is acquired.

Those who *inherit* the predisposition usually belong to families in which the disease is specially rife, and although as children they may have all the appearance of being healthy and even robust, if exposed to infection they are much more liable to contract tuberculosis than are members of families in which the disease is unknown. Children are seldom born with tuberculous lesions, and in the recorded cases of congenital tuberculosis there has almost always been tuberculous disease in the placenta.

There is abundant evidence that the common diseases of infancy and childhood,—such, for example, as whooping-cough, measles, influenza, bronchial catarrh, broncho-pneumonia, and rickets,—by impairing the general health and lowering the resisting powers of the individual, exert an important influence in producing an *acquired* predisposition to tuberculosis. Tuberculous affections frequently date from an attack of one or other of these illnesses, the inflamed and catarrhal condition of the respiratory and other mucous membranes doubtless favouring the occurrence of tuberculous infection. Confinement in crowded dwellings, schoolrooms, workshops, and factories is also injurious, as it entails the breathing of impure air which may be contaminated with tubercle bacilli. Insufficient and improper feeding, by lowering the general vitality and by leading to impairment of digestion and catarrhal changes in the alimentary mucous membranes, has also a prejudicial influence.

In practice it is not uncommon to meet with a combination of the above-mentioned predisposing factors, all conspiring to render the soil more favourable to the growth of tubercle.

Any tissue whose vitality has been lowered by injury or disease furnishes a favourable nidus for the lodgment and growth of tubercle bacilli. The injury or disease, however, is to be looked upon as determining the localisation of the tuberculous lesion rather than as an essential factor in its causation. In a person, for example, in whose blood tubercle bacilli are circulating and reaching every tissue and organ of the body, the occurrence of tuberculous disease in a particular part may be determined by the depression of the tissues resulting from an injury of that part.

Statistics show that the largest number of cases of surgical tuberculosis are met with between the ages of five and fifteen. At the same time, this apparent excessive frequency during the early years of life is partly accounted for by the correspondingly larger number of individuals alive during these years. Stated

in another way, tuberculosis may be comparatively rare above the age of seventy, but so are people. It must be emphasised that tuberculosis may be met with at any period of life; the mere fact that a patient is up in years is not a sufficient reason for excluding the possibility of a given lesion being tuberculous. In children and young adults, surgical tuberculosis is not only pre-eminently curable, but shows a marked tendency towards spontaneous recovery if the patient is placed under favourable conditions. The reparative process is an exceedingly slow one, and the treatment demands patience and perseverance alike from the patient and from the surgeon. In patients past the prime of life, however, there is little tendency to natural recovery from tuberculous affections, and if any operation is performed it must be of a radical character.

While it is a fact that males are, on the whole, more often affected than females, the influence of sex in predisposing to tuberculosis is not understood.

Human and Bovine Tuberculosis.—The view that human and bovine tuberculosis are distinct from one another was promulgated by Koch at the beginning of the present century; since then it has been made the subject of inquiry by many investigators and by a Royal Commission, whose report has just been issued.

It has been established that while the human and the bovine types of bacillus are morphologically indistinguishable, they differ both in their cultural characters and in their pathogenic effects. The chief difference in cultural characters is that the human type shows a greater luxuriance of growth on all ordinary media. As regards their pathogenic characters, the bovine type produces a fatal tuberculosis in cattle, goats, pigs, monkeys, and rabbits; and the human type, while it produces a fatal tuberculosis in guinea-pigs and monkeys, causes only slight non-progressive lesions in cattle, goats, and pigs.

Attempts to transmute the one type of bacillus into the other have hitherto failed, but the possibility of such transmutation under natural conditions cannot be denied.

The fact must be emphasised that in a considerable proportion of cases of tuberculous disease in man the lesions are caused by bacilli of the bovine type; the majority of these cases are met with in childhood, affecting the cervical lymphatic glands, the bones, and the abdominal viscera. Hence the practical importance of strict administrative

measures to prevent the risk of infection from milk and meat derived from tuberculous animals.

Changes in the tissues following upon the successful Lodgment of Tubercle Bacilli.—The action of the bacillus on the tissues is twofold: on the one hand, by its irritation it induces tissue reaction in the form of proliferative changes and leucocyte infiltration; and, on the other, it causes in the cells around degenerative changes which ultimately result in their death.

The area of tissue infected becomes the seat of a chronic inflammation, attended with the formation of a friable, gelatinous granulation tissue. This may be collected into circumscribed nodules or “tubercles,” or it may be ill-defined, diffuse, and infiltrating. This granulation tissue presents characteristic histological elements—for example, large cells, often with more than one nucleus, spoken of as *endothelioid cells*; and still larger cells, known as *giant cells*. There are also large numbers of *small round cells* which resemble the leucocytes of the blood and lymph. It is further characteristic of tuberculous granulation tissue that it tends to undergo certain forms of degeneration and death, of which the most common is *caseation*. This implies the conversion of the tissue into an amorphous, pale-yellow or whitish material resembling cheese. The degeneration and death of the granulation tissue is due partly to the toxins and partly to obliteration of the blood-vessels. Lime salts may subsequently be deposited in this material—a change known as *calcification*.

The recognition of the characteristic elements above described, with or without caseation, is usually sufficient evidence of the tuberculous nature of any portion of tissue examined for diagnostic purposes. The recognition of the bacillus itself by appropriate methods of staining makes the diagnosis a certainty; but as it is by no means easy to identify the organism in many forms of surgical tuberculosis, it may be necessary to have recourse to experimental inoculation of susceptible animals such as guinea-pigs.

The changes subsequent to the formation of tuberculous granulation tissue are liable to many variations. It must always be borne in mind that although the bacilli have effected a lodgment and have inaugurated disease, the relation between them and the tissues remains one of mutual antagonism; which of them is to gain and keep the upper hand in the conflict depends on their relative powers of resistance.

If the tissues prevail, there ensues a process of repair. In

the immediate vicinity of the area of infection young connective tissue, and later, fibrous tissue, is formed. This may entirely replace the tuberculous tissue and bring about repair—a fibrous cicatrix remaining to mark the scene of the previous contest. Scars of this nature are not infrequently discovered at the apex of the lung after death in patients who have at one time suffered from pulmonary phthisis. Under other circumstances, the tuberculous tissue which has undergone caseation, or even calcification, is only encapsulated by the new fibrous tissue, like a foreign body. Although this may be regarded as a victory for the tissues, the cure, if such it may be called, is not necessarily a permanent one, for at any subsequent period of life, if the part affected is disturbed by injury or through some other influence, the encapsulated tubercle may again become active and get the upper hand of the tissues, and there results a relapse or recrudescence of the disease.

If, however, at the inauguration of the tuberculous disease the bacilli prevail, the infection tends to spread into the tissues surrounding those originally infected, and more and more tuberculous granulation tissue is formed. Finally the tuberculous tissue breaks down and liquefies, resulting in the formation of a cold abscess. In their struggle with the tissues, tubercle bacilli receive considerable support and assistance from any pyogenic organisms that may be present. A tuberculous infection may exhibit its aggressive qualities in a more serious manner by sending off detachments of bacilli, which are carried by the lymphatics to the nearest glands, or by the blood-stream to more distant, and it may be to all, parts of the body. When the infection is thus generalised, the condition is called *general tuberculosis*. Considering the extraordinary frequency of localised forms of surgical tuberculosis, general dissemination of the disease is very rare.

The clinical features of surgical tuberculosis will be described with the individual tissues and organs, as they vary so widely according to the situation of the lesion.

The Use of Tuberculin in Diagnosis.—If a subcutaneous injection of Koch's tuberculin, which is a concentrated extract of dead tubercle bacilli, is given to a tuberculous person, it is followed by a severe reaction which is not altogether devoid of danger. The original tuberculin test is still used as a means of diagnosing tuberculous disease in cattle, but it has had to be modified in different ways for use in the human subject.

Von Pirquet's cutaneous reaction is the most easily managed of all the tuberculin tests. Koch's original tuber-

culin is used in a dilution of 25 per cent., and the inner aspect of the forearm is selected as the seat of inoculation. The skin is scratched with a lancet or needle as in vaccinating, and two excoriations separated from each other by at least 5 cms. should be made; a few drops of the solution are gently rubbed over the surface, using a small tampon of cotton wool in catch forceps. A third excoriation into which saline solution is rubbed, should be made as a "control." In tuberculous persons a papule appears in from six to twenty hours, and in forty-eight hours this becomes a round or coffee-bean shaped, raised hyperæmic papule, surrounded by a bright red zone of the size of a florin. The formation of these two zones is to be looked upon as the most reliable evidence of a positive reaction. Resolution begins about the fourth to the sixth day, and in about eight to ten days the swelling has disappeared, but pigmentation remains for some months. In doubtful cases the inoculation should be repeated. The method has the advantage of causing no pain, no increase of temperature, and of being universally applicable. In our experience a negative reaction is almost conclusive proof that the lesion is not tuberculous, as a tuberculous subject seldom fails to give a positive reaction. It is not uncommon to obtain a positive reaction in patients suffering from diseases other than tuberculosis.

The general treatment consists in combating the adverse influences that have been mentioned as increasing the liability to tuberculous infection. Within recent years the value of the "open-air" treatment has been widely recognised. An open-air life, even in the centre of a city, may be followed by marked improvement, especially in the hospital class of patient, whose home surroundings tend to favour the progress of tuberculous disease. The purer air of places away from centres of population is still better; and, according to the idiosyncrasies of the individual patient, mountain air or that of the seacoast may be preferred. In view of the possible discomforts and gastric disturbance which may attend a sea-voyage, this should be recommended to patients suffering from tuberculous lesions with more caution than has hitherto been exercised. The diet must be a liberal one, and should include those articles which are at the same time easily digested and nourishing, especially proteids and fats; milk obtained from a reliable source, and underdone butcher-meat are among the best. When the ordinary nourishment taken is insufficient, it may be supplemented by such articles as malt extract, stout, and cod-liver oil. The last is specially beneficial in patients who do not

take enough fat in other forms. It is noteworthy that many tuberculous patients show an aversion to fat. Cod-liver oil should be given in small quantities until the patient becomes accustomed to it. When the oil in the pure state continues to be distasteful or to disagree, one or other of the emulsified forms may be substituted. The general health may be benefited by the administration of tonics—such, for example, as the syrup of the iodide of iron.

Vaccine Treatment.—The principle underlying the vaccine treatment of tuberculosis is that the cure of the disease depends upon the elaboration by the patient of certain protective substances in sufficient quantities to render the tubercle bacilli innocuous. These bacterioidal substances exert their influence by combining with the chemical constituents of the bacilli, and those described by Wright under the term *opsonins* would appear to be the most important. The injection of a minute dose—one-two-thousandth of a mgrm. ($\frac{1}{20000}$ th) of Koch's new tuberculin, Tuberculin R.—is immediately followed by a lowering of the opsonic index, which indicates that the bactericidal power of the blood is diminished. This "negative phase," however, is soon followed by a "positive phase," the opsonic index being raised, and the bactericidal power of the blood correspondingly increased. The patient thus acquires an increased power of resistance to the tubercle bacilli, which lasts from ten days to a fortnight. A second injection of Tuberculin R. is then made, and by repeated doses the power of resistance may be kept up.

Caution must be exercised in the selection of cases for injection with tuberculin, in the source of the tuberculin, and in the initial doses employed.

In addition to increasing the resisting power of the patient by raising the opsonic index of his blood, it is most important to enable the fluids of the body, so altered, to come into contact with the tuberculous focus. One of the main obstacles to this is that the focus is often surrounded by tissues or fluids which have been almost entirely deprived of bacterioidal substances. In the case of cascated glands in the neck, for example, it is obvious that the removal of this inert material is necessary before the tissues can be irrigated with fluids of high bactericidal value. Again, in tuberculous ascites the abdominal cavity is filled with a fluid practically devoid of anti-bacterial substances, so that the bacilli are able to thrive and work their will on the tissues. When the stagnant fluid is got rid of by laparotomy, the parts are immediately douched with

lymph charged with protective substances, the bactericidal power of which may be many times that of the fluid displaced.

The circulating fluids may be afforded freer access to a tuberculous focus by other means. It is probable that the beneficial influence of *counter-irritants*, such as blisters, and exposure to the *Finsen Light* and other forms of *rays*, is to be attributed in part to the increased flow of blood to the infected tissues.

Bier's hyperæmia.—As has been explained, the induction of hyperæmia by the methods devised by Bier, constitutes one of our most efficient means of combating bacterial infection. The treatment of tuberculosis on this plan has been proved by experience to be a valuable addition to our therapeutic measures, and the simplicity of its application has led to its being widely adopted in practice. It results in an increase in the inflammatory changes around the tuberculous foci, an increase in the immigration of leucocytes, and infiltration with the lymphocytes.

The constricting bandage should be applied at some distance above the seat of infection; for instance, in disease of the wrist, it is put on above the elbow, and it must not cause pain either where it is applied or in the diseased part. The bandage is only applied for a few hours each day, either two hours at a time or twice a day for one hour, and, while it is on, all dressings are removed save a piece of sterile gauze over any wound or sinus that may be present. Joints are not immobilised, and the patient should be encouraged to move the limb. The process of cure takes a long time—nine or even twelve months in the case of a severe joint affection.

In cases in which a constricting bandage is inapplicable, for example, in cold abscesses, tuberculous glands, or tendon sheaths, Klapp's suction bells are employed. The cup is applied for five minutes at a time and then taken off for three minutes, and this is repeated over a period of about three-quarters of an hour. The pus is allowed to escape by a small incision, and no packing or drain should be introduced.

Since the introduction of the methods of treatment described above, and especially by their employment at an early stage in the disease, the number of cases of tuberculosis requiring operative interference has greatly diminished. There are still circumstances, however, in which an operation is required; for example, in disease of the lymphatic glands for the removal of inert masses of caseous material, in disease of bone for the removal of sequestra, or in disease of joints to improve the

function of the limb. It is to be understood, however, that operative treatment must always be preceded by and combined with other therapeutic measures.

TUBERCULOUS ABSCESS

The caseation of tuberculous granulation tissue and its liquefaction into pus is a slow and insidious process, and is unattended with the classical signs of inflammation—hence the terms “cold” and “chronic” applied to the tuberculous abscess.

In a typical cold abscess, such as that which results from tuberculous disease of the vertebræ, the clinical appearances are those of a soft, fluid swelling without heat, redness, pain, or fever. When inflammatory symptoms are present, they are usually due to a mixed infection.

A tuberculous abscess results from the disintegration and liquefaction of tuberculous granulation tissue which has undergone caseation. Fluid and cells from the adjacent blood-vessels exude into the cavity, and lead to variations in the character of its contents. In some cases the contents consist of a clear amber-coloured fluid, in which are suspended fragments of caseated tissue; in others, of a white material like cream-cheese. From the addition of a large number of leucocytes, the contents may resemble the pus of an ordinary abscess.

The wall of the abscess is lined with tuberculous granulation tissue, the inner layers of which are undergoing caseation and disintegration, and present a shreddy appearance; the outer layers consist of tuberculous tissue which has not yet undergone caseation. The abscess tends to increase in size by progressive liquefaction of the inner layers, caseation of the outer layers, and the further invasion of the surrounding tissues by tubercle bacilli. In this way a tuberculous abscess is capable of indefinite extension and increase in size until it reaches a free surface and ruptures externally. The direction in which it spreads is influenced by the anatomical arrangement of the tissues, and possibly to some extent by gravity, and the abscess may reach the surface at a considerable distance from its seat of origin. The best illustration of this is seen in psoas abscess, which may originate in the dorsal vertebræ, extend downwards within the sheath of the psoas muscle, and finally appear in the thigh.

Clinical Features.—The insidious development of the tuber-

culous abscess is one of its most characteristic features. The swelling may attain a considerable size without the patient being aware of its existence, and, as a matter of fact, it is often discovered accidentally. There is an absence of the ordinary signs of inflammation; but if during the development and progress of the abscess the patient is under observation, and a record kept of the daily temperature, a slight evening rise may be noted. There is usually a quiescent stage of the tuberculous abscess, which is not attended with any rise of temperature. According to its situation and mode of origin, the abscess varies in size from a small cherry to a cavity containing several pints of pus. The shape of the abscess varies; it is usually that of a flattened sphere, but it may present pockets or burrows running in various directions. Sometimes the abscess is hour-glass or dumb-bell shaped; this is well illustrated in the region of the groin in disease of the spine or pelvis, where there may be one large sac occupying the venter ilii, and a smaller one in the thigh, the two communicating by a narrow channel under Poupart's ligament. By pressing with the fingers the pus may be displaced from one compartment to the other. Occasionally the progress of the abscess is arrested, and it remains stationary for an indefinite period. The usual course of events, however, is that the abscess progresses slowly, and finally reaches a free surface—usually the skin. As it does so there may be some pain, redness, and local elevation of temperature. Fluctuation becomes more evident and superficial, and the skin becomes livid and finally gives way. If the case is left to nature, the discharge of pus continues, and the track opening on the skin surface remains as a *sinus*. The persistence of suppuration is due to the presence in the wall of the abscess and of the sinus, of tuberculous granulation tissue, which, so long as it remains, continues to furnish discharge, and so prevents healing. Sooner or later pyogenic organisms gain access to the sinus, and through it to the wall of the abscess. They tend further to depress the resisting power of the tissues, and thereby aggravate and perpetuate the tuberculous disease. This superadded infection with pyogenic organisms exposes the patient to the further risks of septic intoxication, especially in the form of hectic fever and septicæmia, and increases the liability to general tuberculosis, and to waxy degeneration of the internal organs. A tuberculous abscess may in one or other of these ways be a cause of death.

A chronic abscess may be met with anywhere in the subcutaneous or other cellular tissue. It is often the result

of tuberculous disease in a lymphatic gland, in a bone, or in one or other of the organs of the body, such as the kidney or testicle.

Residual abscess is the name given to an abscess which may make its appearance months, or even years, after the apparent cure of tuberculous disease—as, for example, in the hip-joint or spine. It is called residual because it has its origin in the residuum or remains of the original disease.

Diagnosis.—A cold abscess in the quiescent stage is to be diagnosed from a syphilitic gumma, a cyst, a lipoma, and from other soft tumours. The differential diagnosis of these affections will be considered later. When it is about to burst externally, it may be difficult to distinguish a tuberculous abscess from an abscess due to infection with pyogenic organisms. Help is obtained by the history, and by recognising the association of the abscess with tuberculous disease in one of the organs in the neighbourhood. Even when the abscess is opened, the appearances of the pus may not supply the desired information, and it may be necessary to submit it to bacteriological examination. When the pus is found to be sterile, it is usually safe to assume that the condition is tuberculous, as in other forms of suppuration the causative organisms can usually be recognised. Experimental inoculation may enable us to arrive at a definite diagnosis, but it implies a delay of two to three weeks.

Treatment.—The tuberculous abscess may recede and disappear under the treatment employed for tuberculosis in general, and this should always precede and accompany any procedure directed to the abscess itself. Many surgeons advise that so long as the abscess is quiescent it should be left alone. All agree, however, that if it shows a tendency to spread, to increase in size, or to approach the skin or mucous membrane, something should be done to avoid the danger of its bursting and becoming infected with pyogenic organisms. Simple evacuation of the abscess by a hollow needle may suffice, or iodoform may be introduced after withdrawal of the contents.

Evacuation of the Abscess and Injection of Iodoform.—The iodoform is employed in the form of a 10 per cent. solution in ether or the same proportion suspended in glycerin. Either form becomes sterile soon after it is prepared. Its curative effects would appear to depend upon the liberation of iodine, which restrains the activity of the bacilli, and upon its capacity for irritating the tissues and so inducing a protective leucocytosis, and also of stimulating the formation of scar tissue. An

anæsthetic is rarely called for, except in children. The abscess is first evacuated by means of a large trocar and cannula introduced obliquely through the overlying soft parts, avoiding any part where the skin is thin or red. If the cannula becomes blocked with caseous material, it may be cleared with a probe, or a small quantity of saline solution is forced in by the syringe. The iodoform is injected by means of a glass-barrelled syringe, which is firmly screwed on to the cannula. The amount injected varies with the size of the abscess and the age of the patient; it may be said to range from two or three drams in the case of children to several ounces in large abscesses in adults. The cannula is then withdrawn, and the puncture covered with a gauze dressing, and bandaged so as to exert a certain amount of compression. If the abscess fills up again, the procedure should be repeated.

When the contents of the abscess are semi-solid, and cannot be withdrawn even through a large cannula, a small incision must be made, and, after emptying the cavity, the iodoform is introduced through a short rubber tube attached to the syringe. The injection is continued while the wound is being closed with sutures, so that when the operation is completed the cavity will be distended with the fluid. The method is only satisfactory if the wound heals by first intention. Experience has shown that even large abscesses, such as those associated with spinal disease, may be cured by iodoform injection, and this even when rupture of the abscess on the skin surface has appeared to be imminent.

Another method of treatment which is less popular now than it used to be, and which is chiefly applicable in abscesses of moderate size, is by *incision of the abscess and removal of the tuberculous tissue in its wall* with the sharp spoon. An incision is made which will give free access to the interior of the abscess, so that outlying pockets or recesses may not be overlooked. After removal of the pus, the walls of the abscess are scraped with the Volkmann spoon or with Barker's flushing spoon, to get rid of the tuberculous tissue with which they are lined. In using the spoon, care must be taken that its sharp edge does not perforate the wall of a vein or other important structure. Any debris which may adhere to the walls is removed by rubbing with dry gauze. The oozing of blood is arrested by packing the cavity for a few minutes with gauze. After the packing is removed, iodoform powder is rubbed into the raw surface. The soft parts divided by the incision are sutured in layers so as to ensure primary union. If, on the other hand,



FIG. 35.—Tuberculous Sinus injected through its opening in the forearm with Bismuth paste.
(Mr. Pirie Watson's case—Radiogram by Dr. Hope Fowler.)

there is fear of a mixed infection, it is safer to treat it by the open method, packing the cavity with iodoform worsted, which is renewed at intervals as the cavity heals from the bottom.

When the skin over the abscess is red, thin, and about to give way, as is frequently the case when the abscess is situated in the subcutaneous cellular tissue, any skin which is undermined and infected with tubercle should be removed with the scissors at the same time that the abscess is incised.

In abscesses treated by the open method, when the cavity has become lined with healthy granulations, it may be closed by secondary suture, or, if the granulating surface is flush with the skin, healing may be hastened by skin-grafting.

If the tuberculous abscess has burst and left a *sinus*, this is apt to persist because of the presence of tuberculous tissue in its walls, and of superadded pyogenic infection, or because it serves as an avenue for the escape of discharge from a focus of tubercle in a bone or lymphatic gland.

The treatment varies with the conditions present, and must include measures directed to the lesion from which the sinus has originated. The extent and direction of any given sinus may be demonstrated by the use of the probe, or, more accurately, by injecting the sinus with a paste consisting of white vaseline containing 10 per cent. of bismuth subnitrate, or sub-carbonate, and following its track with the X-rays. (Fig. 35.)

It has been found by Beck of Chicago that the injection of bismuth paste is frequently followed by healing of the sinus, and that, if one injection fails to bring about a cure, repeating the injections every second day may be successful. Some caution must be observed in this treatment by bismuth, as symptoms of poisoning have been observed to follow its use. Should they manifest themselves, an injection of warm olive-oil should be given; the oil, left in for twelve hours or so, forms an emulsion with the bismuth, which can be withdrawn by aspiration. Iodoform suspended in glycerin may be employed in a similar manner. When these and other non-operative measures fail, and the whole track of the sinus is accessible, it should be laid open, scraped, and packed with gauze until it heals from the bottom.

The *tuberculous ulcer* is described in the chapter on ulcers.

CHAPTER X

SYPHILIS

Definition.—Virus.—ACQUIRED SYPHILIS—Primary period: *Incubation, primary chancre, glandular enlargement, extra-genital chancres*—Treatment—Secondary period: *General symptoms, skin affections, mucous patches, affections of bones, joints, eyes, etc.*—Treatment: *Methods of administering mercury—Salvarsan*—Syphilis and marriage—Intermediate stage—Reminders—Tertiary period: *General symptoms, gummata, tertiary ulcers, tertiary lesions of skin, mucous membrane, bones, joints, etc.*—Second attacks.—INHERITED SYPHILIS—Transmission—*Clinical features in infancy, in later life*—Contagiousness—Treatment.

SYPHILIS is an infective disease due to the entrance into the body of a specific virus. It is nearly always communicated from one individual to another by contact infection, the discharge from a syphilitic lesion being the medium through which the virus is transmitted, and the seat of inoculation is almost invariably a surface covered by squamous epithelium. The disease was unknown in Europe before the year 1493, when it was introduced into Spain by Columbus' crew, who were infected in Haiti, where the disease had been endemic from time immemorial (Bloch).

Syphilis combines the characters of a specific fever running a chronic course with those of an infective granuloma. The granulation tissue which forms as a result of the reaction of the tissues to the presence of the virus is chiefly composed of lymphocytes and plasma cells, along with an abundant new formation of capillary blood-vessels. Giant cells are not uncommon, but the endothelioid cells, which are so marked a feature of tuberculous granulation tissue, are practically absent.

When syphilis is communicated from one individual to another by contact infection, the condition is spoken of as *acquired syphilis*, and the first visible sign of the disease appears at the site of inoculation, and is known as *the primary lesion*. Those who have thus acquired the disease may

transmit it to their offspring, who are then said to suffer from *inherited syphilis*.

The Virus of Syphilis.—The cause of syphilis, whether acquired or inherited, is the organism, described by Schaudinn and Hoffman, in 1905, under the name of *spirochæte pallida* or *treponema pallidum*. It is a delicate, thread-like spirilla, in length averaging from 4 to 14 μ and in width about $\cdot 25 \mu$, and is distinguished from other spirochætes by its delicate

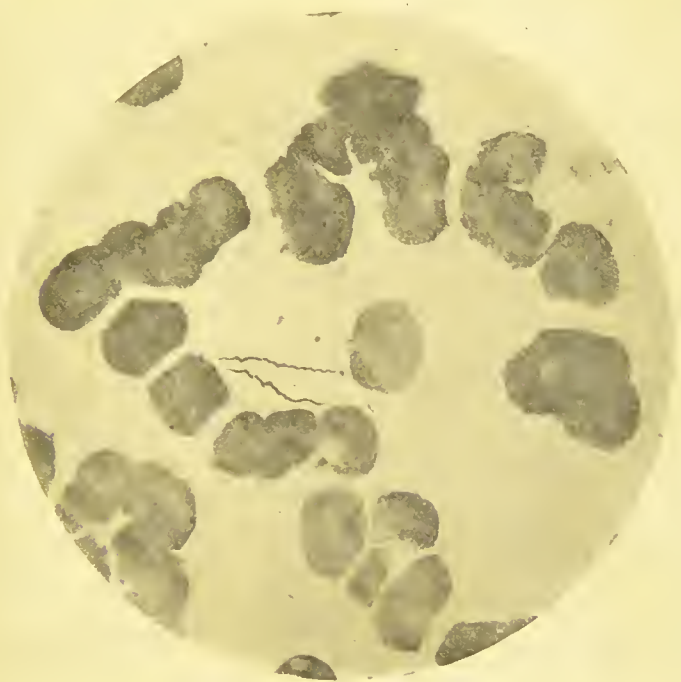


FIG. 36.—*Spirochæte pallida*. $\times 1000$ diam. Two specimens in centre of field, surrounded by red blood corpuscles.

(From specimen lent by Dr. Theodore Shennan.)

shape, its slight refractive power, together with its typical spiral form, with numerous undulations (10 to 26), which are perfectly regular, and are characteristic in that they remain the same during rest and in active movement. The organism thins out at each pole, and is continued in the form of a long cilium; it is readily destroyed by heat, and perishes in the absence of moisture. In a fresh specimen, such as a scraping from a hard chancre suspended in a little salt solution, the organism shows active movements. It has been proved experimentally that the virus remains efficacious only up to six hours after its removal

from the body. It has not yet been cultivated from syphilitic lesions in the human subject, but Noguchi has succeeded in obtaining pure cultures from the infected tissues of the rabbit.

The spirochæte may be recognised in films made by scraping the deeper parts of the primary lesion, or from blisters artificially raised on lesions of the skin or on the immediately adjacent portion of healthy skin. It is best stained by Giemsa's method, and its recognition is greatly aided by the use of the ultra-microscope.

The spirochæte has been demonstrated in every form of syphilitic lesion, and has been isolated from the blood and

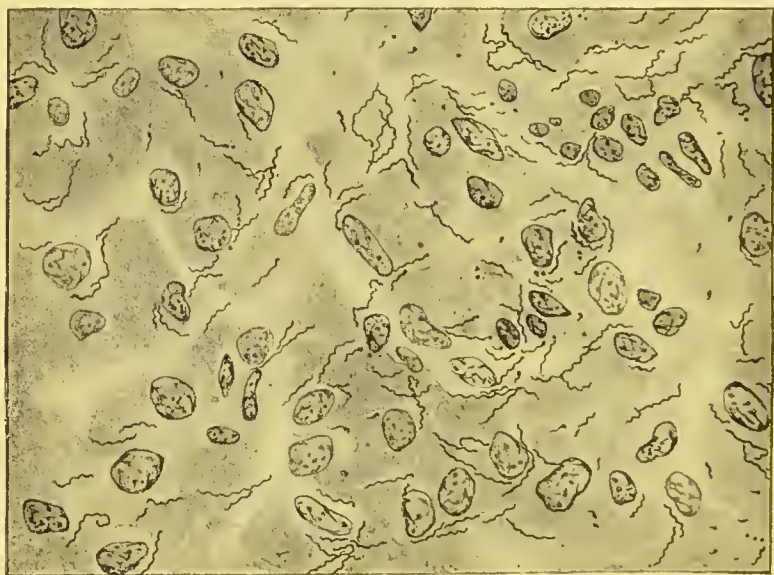


FIG. 37.—*Spirochaeta pallida* in Liver of new-born child.¹

from lymph withdrawn by a hypodermic needle from enlarged lymphatic glands. The saliva of persons suffering from syphilitic lesions of the mouth also contains the organism.

In tertiary lesions there is greater difficulty in demonstrating the spirochæte, but small numbers have been found in the peripheral parts of gummata and in the thickened patches in syphilitic disease of the aorta. In such *para-syphilitic affections* as general paralysis and tabes the organism has not been discovered. The spirochæte may persist in the body for a long time after infection; in one case its presence was demonstrated sixteen years after the original acquisition of the disease.

¹ From *A System of Syphilis*, Metchnikoff, Oxford Medical Publications.

In inherited syphilis the spirochæte is present in enormous numbers throughout all the organs and fluids of the body (Fig. 37).

Considerable interest attaches to the observations of Metchnikoff, Roux, and Neisser, who have succeeded in conveying syphilis to the chimpanzee and other members of the ape tribe, obtaining primary and secondary lesions similar to those observed in man, and also containing the spirochæte. The number of experiments on these animals is now very great, and the general result is that the disease has been transmitted by material from all kinds of syphilitic lesions, including even the blood in the secondary and tertiary stages of the disease. The primary lesion is in the form of an indurated papule, in every respect resembling the corresponding lesion in man, and associated with enlargement and induration of the lymphatic glands. The primary lesion usually appears about thirty days after inoculation, to be followed, in about half the cases, by secondary manifestations, which are usually of a mild character; in no instance has any tertiary lesion been observed. The severity of the affection amongst apes would appear to be in proportion to the nearness of the relationship of the animal to the human subject. The eye of the rabbit is also susceptible to inoculation from syphilitic lesions; the material in a finely divided state is introduced into the anterior chamber of the eye.

Attempts to immunise against the disease have so far proved negative, but Metchnikoff has shown that the inunction of the part inoculated with an ointment containing 25 per cent. of calomel, within twenty hours of infection, suffices to neutralise the virus. He recommends the adoption of this procedure in the prophylaxis of syphilis. Experiments on apes justify the expectation that the employment of an attenuated virus as a vaccine may modify the course of the disease.

ACQUIRED SYPHILIS

In the vast majority of cases, infection takes place during the congress of the sexes. Delicate, easily abraded surfaces are then brought into contact, and the discharge from lesions containing the virus is placed under favourable conditions for conveying the disease from one person to the other. In the male the possibility of infection taking place is increased if the virus is retained under cover of a long and tight prepuce, and if there are abrasions on the surface with which it comes in

contact. The frequency with which infection takes place on the genitals during sexual intercourse warrants syphilis being considered a venereal disease, although there are other ways in which it may be contracted.

Some of these imply direct contact—such, for example, as kissing, the digital examination of syphilitic patients by doctors or nurses, or infection of the surgeon's fingers while operating upon a syphilitic patient. In suckling, a syphilitic wet nurse may infect a healthy infant, or a syphilitic infant may infect a healthy wet nurse. In other cases the infection is by indirect contact, the virus being conveyed through the medium of articles contaminated by a syphilitic patient—such, for example, as surgical instruments, tobacco pipes, wind instruments, table utensils, towels, or underclothing. Physiological secretions, such as saliva, milk, or tears, are not capable of communicating the disease unless contaminated by discharge from a syphilitic sore. While the saliva itself is innocuous, it can be, and often is, contaminated by the discharge from mucous patches or other syphilitic lesions in the mouth and throat, and is then a dangerous medium of infection. Unless these extra-genital sources of infection are borne in mind, there is a danger of failing to recognise the primary lesion of syphilis in unusual positions, such as the lip, finger, or nipple. When the disease is thus acquired by innocent transfer, it is known as *syphilis insontium*.

Stages or Periods of Syphilis.—Following the teaching of Ricord, it is customary to divide the life-history of syphilis into three periods or stages, referred to, for convenience, as primary, secondary, and tertiary. This division is to some extent arbitrary and artificial, as the different stages overlap one another, and the lesions of one stage merge insensibly into those of another. Wide variations are met with in the manifestations of the secondary stage, and histologically there is no valid distinction to be drawn between secondary and tertiary lesions.

The primary period embraces the interval that elapses between the initial infection and the first constitutional manifestations,—roughly, from four to eight weeks,—and includes the period of incubation, the development of the primary sore, and the enlargement of the nearest lymphatic glands.

The secondary period varies in duration from one to two years, during which time the patient is liable to suffer from manifestations which are for the most part superficial in

character, affecting the skin and its appendages, the mucous membranes, and the lymphatic glands.

The tertiary period has no time-limit except that it follows upon the secondary, so that during the remainder of his life the patient is liable to suffer from manifestations which may affect the deeper tissues and internal organs as well as the skin and mucous membranes.

Primary Syphilis.—*The period of incubation* represents the interval that elapses between the occurrence of infection and the appearance of the primary sore at the site of inoculation. Its limits may be stated as varying from two to six weeks, with an average of from twenty-one to twenty-eight days. While the affection is incubating, there is nothing to show that the patient has contracted any disease.

The Primary Lesion.—The incubation period having elapsed, there appears at the site of inoculation a circumscribed area of infiltration which represents the reaction of the tissues to the entrance of the virus. The first appearance is that of a sharply defined papule, rarely larger than a split pea. Its surface is at first smooth and shiny, but as necrosis of the tissue elements takes place in the centre, it becomes concave, and in many cases the epithelium is shed and an ulcer is formed. Such an ulcer has an elevated border, sharply cut edges, an indurated base, and exudes a scanty serous discharge; its surface is at first occupied by yellow necrosed tissue, but in time this is replaced by smooth, pale-pink granulation tissue; finally, epithelium may spread over the surface, and the ulcer heals. As a rule the patient suffers little discomfort, and may even be ignorant of the existence of the lesion, unless, as a result of exposure to mechanical or septic irritation, ulceration ensues, and the sore becomes painful and tender, and yields a purulent discharge. The primary lesion may persist until the secondary manifestations make their appearance.

It cannot be emphasised too strongly that the induration of the primary lesion, which has obtained for it the name of "hard chancre," is its most important characteristic. It is best appreciated when the sore is grasped from side to side between the finger and thumb. The sensation on grasping it has been aptly compared to that imparted by a nodule of cartilage, or by a button felt through a layer of cloth. The evidence obtained by touch is more valuable than that obtained by inspection, a fact which is made use of in the recognition of *concealed chancres*—that is, those which are hidden by a tight prepuce. The induration is due not only to the dense packing of the

connective-tissue spaces with lymphocytes and plasma cells, but to the formation of new connective-tissue elements. It is most marked in relation to chancres situated in the furrow between the glans and the prepuce.

In the male, the primary lesion specially affects certain situations, and the appearances vary with these:—(1) On the inner aspect of the prepuce, and in the fold between the prepuce and the glans; in the latter situation the induration imparts a “collar-like” rigidity to the prepuce, which is most apparent when it is rolled back over the corona. (2) At the orifice of the prepuce the primary lesion assumes the form of multiple linear ulcers or fissures, and as each of these is attended with infiltration, the prepuce cannot be pulled back—a condition known as syphilitic phimosis. (3) On the glans penis the infiltration may be so superficial that it resembles a layer of parchment, but if it invades the cavernous tissue there is a dense mass of induration. (4) On the external aspect of the prepuce or on the skin of the penis itself. (5) At either end of the torn frænum, in the form of a diamond-shaped ulcer raised above the surroundings. (6) In relation to the meatus and canal of the urethra, in either of which situations the swelling and induration may lead to narrowing of the urethra, so that the urine is passed with pain and difficulty and in a very minute stream; stricture results only in the exceptional cases in which the chancre has ulcerated and caused destruction of tissue. A chancre within the orifice of the urethra is very rare, and, being concealed from view, its existence is recognised by the discharge from the meatus and by the induration felt between the finger and thumb on palpating the urethra.

In the female, the primary lesion is not so typical or so easily recognised as in men; it is usually met with on the labia; and the induration is rarely characteristic and does not last so long; often there are several indurated nodules, and, according to Arthur Ward, the primary lesion may take the form of condylomata.

The hard chancre is usually solitary, but cases are met with in which there are two or more; when there are several, they are individually smaller than the solitary chancre.

It is rather the exception for a hard chancre to leave a visible scar, hence, in examining patients with a doubtful history of syphilis, little reliance can be placed on the presence or absence of a scar on the genitals. When the primary lesion has taken the form of an open ulcer with purulent discharge, or has sloughed, there is a permanent scar.

Infection of the adjacent lymphatic glands is usually found to have taken place by the time the primary lesion has acquired its characteristic induration. Several of the glands along Poupart's ligament, on one or on both sides, become enlarged, rounded, and indurated; they are usually freely movable, and are rarely sensitive unless there is superadded septic infection. The term *bullet-bubo* has been applied to them, and their presence is of great value in diagnosis. In a certain number of cases, one of the main lymphatic vessels on the dorsum of the penis is transformed into a fibrous cord easily recognisable on palpation, and when grasped between the fingers appears to be in size and consistence not unlike the vas deferens.

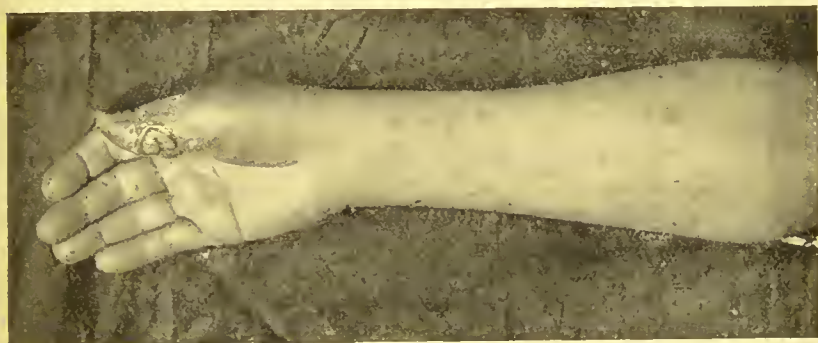


FIG. 38.—Primary Lesion on Thumb, with Secondary Eruption on Forearm.¹

Concealed chancre is the term applied when one or more chancres are situated within the sac of a prepuce which cannot be retracted. If the induration is well marked, the chancre can be palpated through the prepuce, and is tender on pressure. As under these conditions it is impossible for the patient to keep the parts clean, septic infection becomes a prominent feature, the prepuce is cedematous and inflamed, and there is an abundant discharge of pus from its orifice. It occasionally happens that the septic infection assumes a virulent character and causes sloughing of the prepuce—a condition known as *phagedæna*. The discharge is then foul and blood-stained, and the prepuce becomes of a dusky red or purple colour, and may finally slough, exposing the glans.

Extra-genital or Erratic Chancres (Fig. 38).—Erratic chancre is the term applied by Jonathan Hutchinson to the primary

¹ From *A System of Syphilis*, vol. ii., edited by D'Arcy Power and J. Keogh Murphy, Oxford Medical Publications.

lesion of syphilis when it appears on parts of the body other than the genitals. It differs in some respects from the hard chancre as met with on the penis; it is usually larger, the induration is more diffused, and the enlarged glands are softer and more sensitive. The glands in nearest relation to the sore are those first affected, for example, the epitrochlear or axillary glands in chancre of the finger; the submaxillary glands in chancre of the lip or mouth; or the pre-auricular gland in chancre of the eyelid or forehead. In consequence of their divergence from the typical chancre, and of their being often met with in persons who, from age, surroundings, or moral character, are unlikely subjects of venereal disease, the true nature of erratic chancres is often overlooked until the persistence of the lesion, its want of resemblance to anything else, or the onset of constitutional symptoms, determines the diagnosis of syphilis. A solitary, indolent sore occurring on the lip, eyelid, finger, or nipple, which does not heal but tends to increase in size, and is associated with induration and enlargement of the adjacent glands, is most likely to be the primary lesion of syphilis.

The Soft Sore, Soft Chancre, or Chancroid.—The differential diagnosis of syphilis necessitates the consideration of the *soft sore, soft chancre, or chancroid*, which is also a common form of venereal disease, and is due to infection with a virulent pus-forming bacillus, first described by Ducrey in 1889. Ducrey's bacillus occurs in the form of minute oval rods measuring about $1.5\ \mu$ in length, which stain readily with any basic aniline dye, but are quickly decolorised by Gram's method. They are found mixed with other organisms in the purulent discharge from the surface, and are chiefly arranged in small groups or in short chains. Soft sores are always contracted by direct contact from another individual, and the incubation period is a short one of from two to five days. The sores are most often situated in the vicinity of the frænum of the prepuce, and, in women, about the labia minora or fourchette; they probably originate in abrasions in these situations. They appear as pustules, which are rapidly converted into small, acutely inflamed ulcers with sharply cut, irregular margins, and yielding an abundant yellow purulent discharge. They are devoid of the characteristic induration of syphilis, are painful, and nearly always multiple, reproducing themselves in successive crops by auto-inoculation. Soft sores are often complicated by phimosis and balanitis, and they frequently lead to infection of the glands in the groin. The

resulting bubo is different from that due to syphilis; it is ill-defined, painful, and very tender, and suppuration occurs in about one-fourth of the cases. The overlying skin becomes adherent and red, and suppuration takes place either in the form of separate foci in the interior of the individual glands, or around them; in the latter case, on incision, the glands are found lying bathed in pus. Ducrey's bacillus is found in the bubo in a state of purity; it has been demonstrated by microscopic examination and by culture. Sometimes the ordinary pyogenic organisms are superadded. After the bubo has been opened the wound may take on the characters of a soft sore.

Soft sores heal rapidly when kept thoroughly clean. They should be washed with peroxide of hydrogen, and dusted with an antiseptic powder such as a mixture of one part iodoform and two parts boracic or salicylic acid, or, when the odour of iodoform is objected to, of equal parts of boracic acid and carbonate of zinc. The sore is then covered with a piece of gauze kept in position by drawing the prepuce over it, or by a few turns of a narrow bandage. If the sores spread in spite of this, they should be painted with cocaine and then cauterised. If there is phimosis with balanitis, the prepuce must either be washed out with hydrogen peroxide at frequent intervals, or removed by circumcision; in the latter case, bluestone should be rubbed into the raw surface made at the operation, lest it also should take on the characters of a soft sore. When the glands in the groin become inflamed, the patient must be confined to bed, and a dressing impregnated with ichthyol and glycerin (10 per cent.) applied; the repeated use of Klapp's suction apparatus (p. 48) is of great service, and if suppuration takes place, the pus is let out by one or more small incisions and the use of the suction apparatus continued.

Diagnosis of Primary Syphilis.—In typical cases in which there is a clear history of an incubation period of from three to five weeks, when the sore is indurated, persistent, and indolent, and attended with bullet-buboes in the groin, the diagnosis of primary syphilis is not difficult. It is important to bear in mind *the possibility of a patient having acquired a mixed infection* with the virus of soft chancre, which will manifest itself a few days after infection, and the virus of syphilis, which shows itself after an interval of several weeks. This occurrence was formerly the source of much confusion in diagnosis, and it was believed at one time that syphilis might result from soft sores, but we now know that syphilis does not follow upon soft sores unless the virus of

syphilis has been introduced at the same time. The practitioner must be on his guard, therefore, when a patient asks his advice concerning a venereal sore which has appeared within a few days of exposure to infection. Such a patient is naturally anxious to know whether he has contracted syphilis or not, but neither a positive nor a negative answer can be given until the incubation period of syphilis has elapsed—that is, until after an interval of four or five weeks, unless the spirochæte can be identified in a scraping from the sore.

Syphilis is also to be diagnosed from *epithelioma*, the common form of cancer of the penis. It is especially in elderly patients with a tight prepuce that the induration of epithelioma is liable to be mistaken for that associated with syphilis. In difficult cases the prepuce must be slit open, or the patient kept under observation until the effects of treatment can be ascertained, as the chancre readily yields to anti-syphilitic remedies.

Difficulty may occur in the diagnosis of primary syphilis from *herpes*, as this may appear as late as ten days after connection; it commences as a group of vesicles which soon burst and leave shallow ulcers with a yellow floor; these disappear quickly on the use of an antiseptic dusting powder.

Apprehensive patients who have committed sexual indiscretions are apt to regard as syphilitic any lesion which happens to be located on the penis—for example, acne pustules, eczema, psoriasis papules, boils, balanitis, or venereal warts.

Treatment of Primary Syphilis.—Reference may be made in the first instance to the question of excising or destroying the primary lesion with a view to preventing general infection. As a matter of fact, this question very rarely arises in practice, because by the time the chancre has sufficiently developed to be diagnosed with certainty, the virus has already entered the lymphatics. When the chancre is situated on the prepuce, however, it may be an advantage to perform circumcision, but without holding out any certain hope of preventing constitutional infection. In the case of chancres which cannot be removed by circumcising the patient, attempts have been made to prevent constitutional infection by injecting into the tissues around the lesion a mercurial preparation which will destroy the spirochætes.

When the diagnosis of syphilis is established, we agree with those who, regarding mercury as the best-known antidote to the virus of syphilis, aim at bringing the patient under the influence of the drug before the disease has become generalised.

The methods of administering it will be described with the treatment of secondary syphilis.

The local treatment chiefly consists in the maintenance of cleanliness. The part is washed night and morning, preferably with peroxide of hydrogen; if the surface is unbroken, it may be dusted lightly with a powder composed of equal parts of calomel and carbonate of zinc. If there is an ulcer, the best application is a piece of lint or gauze soaked in black wash, renewed night and morning, or oftener if there is much discharge, and kept in place either by drawing the prepuce over it or by a few turns of narrow bandage or plaster. The penis and scrotum should be supported against the abdominal wall by a triangular handkerchief or bathing-drawers, and if there is inflammatory œdema the patient should be confined to bed.

In *concealed chancres* with phimosis, the sac of the prepuce should be frequently washed out, by means of a syringe, with sublimate lotion (1-2000) or peroxide of hydrogen, and the sac packed with a strip of lint soaked in black wash so as to separate the prepuce from the glans. If this does not eliminate the septic element, it is better to circumcise the patient and thus obtain free access to the lesion. If phagedæna occurs, the prepuce must be slit open along the dorsum, or if sloughing, cut away, and the patient should have frequent sitz baths of weak sublimate lotion. When the chancre is within the meatus, iodoform bougies are inserted into the urethra, and the urine should be rendered bland by drinking large quantities of fluid.

Secondary Syphilis.—The following description of secondary syphilis is based on the average course of the disease in untreated cases. The onset of constitutional symptoms occurs from six to twelve weeks after the original infection, and the manifestations are the result of the entrance of the virus into the general circulation, and its being carried to all parts of the body. The period during which the patient is liable to suffer from secondary symptoms varies from six months to two years.

In some cases the general health is not disturbed; in others the patient is feverish and out of sorts, losing appetite, becoming pale and anæmic, complaining of lassitude, incapacity for exertion, headache, and pains of a rheumatic type referred to the bones. There is a moderate degree of leucocytosis, but the increase is due not to the polymorphonuclear leucocytes but to lymphocytes. In isolated cases the temperature rises

to 101° or 102° F. and the patient loses flesh. The lymphatic glands accessible to palpation, particularly those along the posterior border of the sterno-mastoid, become enlarged and slightly tender. The hair comes out, eruptions appear on the skin and mucous membranes, and the patient may suffer from sore throat and affections of the eyes. The local lesions are to be regarded as being of the nature of reactions against accumulations of the parasite, lymphocytes and plasma cells being the elements chiefly concerned in the reactive process.

Affections of the Skin are among the most constant manifestations of secondary syphilis. An evanescent macular rash, not unlike that of measles—*roseola*—is the first to appear, usually in from six to eight weeks from the date of infection; it is widely diffused over both aspects of the trunk, and the original dull rose-colour soon fades, leaving brownish stains, which in time disappear. It is usually followed by a *papular eruption*, the individual papules being raised above the surface of the skin, smooth or scaly, and as they are due to infiltration of the skin they are more persistent than the roseoles. They vary in size and distribution, being sometimes small, hard, polished, and closely aggregated like lichen, sometimes as large as a shilling-piece, with an accumulation of scales on the surface like that seen in psoriasis. The co-existence of scaly papules and faded roseoles is very suggestive of syphilis.

Other types of eruption are less common, and are met with from the third month onwards. A *pustular* eruption, not unlike that of acne or of chicken-pox, is sometimes a prominent feature, but is not characteristic of syphilis unless it affects the scalp and forehead and is associated with the remains of the papular eruption. The term *ecthyma* is applied when the pustules are of large size, and, after breaking on the surface, give rise to superficial ulcers; the discharge from the ulcer often dries up and forms a scab or crust which is continually added to from below as the ulcer extends in area and depth. The term *rupia* is applied when the crusts are prominent, dark in colour, and conical in shape, roughly resembling the shell of a limpet. If the crust is detached, a sharply defined ulcer is exposed, and when this heals it leaves a scar which is usually circular, thin, white, shining like satin, and the surrounding skin is darkly pigmented; in the case of deep ulcers, the scar is depressed and fixed. The student must be prepared to meet with all gradations of skin lesions from papules to punched-out ulcers, and should regard a combination of the different types as suggestive of syphilis.

In the later stages there may occur a form of creeping or *spreading ulceration of the skin* of the face, groin, or scrotum, healing at one edge and spreading at another like tuberculous lupus, but distinguished from this by its much more rapid progress and by the pigmentation of the scar.

Condylomata are probably more characteristic of syphilis than any other type of skin lesion. They are papules occurring on those parts of the body where the skin is habitually moist, and especially where two skin surfaces are in contact. They



FIG. 39.—Syphilitic Rupia.

are chiefly met with in relation to the external genitals, especially in women, around the anus, beneath large pendulous mammæ, between the toes, and at the angles of the mouth, and in these situations their development is greatly favoured by neglect of cleanliness. They present the appearance of well-defined circular or ovoid areas in which the skin is thickened and raised above the surface; they are covered with a white sodden epidermis, and furnish a scanty but very infective discharge. Under the influence of irritation and want of rest, as at the anus or at the angle of the mouth, they are apt to

become fissured and superficially ulcerated, and the discharge then becomes more abundant, and may crust on the surface, forming yellow scabs. At the angle of the mouth the condylomatous patches may spread to the cheek, and when they ulcerate may leave numerous fissure-like scars radiating from the mouth—an appearance best seen in inherited syphilis (Fig. 42).

The Appendages of the Skin.—The hair loses its gloss, becomes dry and brittle, and readily falls out, either as an exaggeration of the normal shedding of the hair, or in scattered areas over the scalp. The hair is not re-formed in the scars which result from ulcerated lesions of the scalp. The nail-folds occasionally present a pustular eruption and superficial ulceration, to which the name *syphilitic onychia* has been applied; more commonly the nails become brittle and ragged, and they may even be shed.

The Mucous Membranes, and especially those of the mouth and throat, suffer from lesions similar to those met with on the skin. On a mucous surface the papular eruption assumes the form of *mucous patches*, which are areas with a congested base covered with a thin white film of sodden epithelium like wet tissue-paper. They are best seen on the inner aspect of the cheeks, the soft palate, uvula, pillars of the fauces, and tonsils. When a mucous patch is in contact with a rough tooth, it may give way on the surface and ulcerate. In addition to mucous patches, there may be a number of small, *superficial, kidney-shaped ulcers*, especially along the margins of the tongue and on the tonsils. In the absence of mucous patches and ulcers, the sore throat may be characterised by a bluish tinge of the inflamed mucous membrane and a thin film of shed epithelium on the surface. Sometimes there is an elongated sinuous film which has been likened to the track of a snail. In the *larynx* the presence of congestion, cedema, and mucous patches may be the cause of persistent hoarseness. The *tongue* often presents a combination of lesions, including ulcers, patches where the papillæ are absent, fissures, and raised white papules resembling warts, especially towards the centre of the dorsum. These lesions are specially apt to occur in those who smoke, drink, or eat hot condiments to excess, and in those with irregular, sharp-cornered teeth. At a later period, and in those who are broken down in health from intemperance or other cause, the sore throat may take the form of rapidly spreading, penetrating ulcers in the soft palate and pillars of the fauces, which may lead to extensive destruction of tissue.

In exceptional cases, an ulceration commencing in the fauces spreads forwards along the palate and destroys the entire roof of the mouth.

In the *bones*, lesions occur which assume the clinical features of an evanescent periostitis, the patient complaining of nocturnal pains over the frontal bone, sternum, tibiæ and ulnæ, and localised tenderness on tapping over these bones.

In the *joints*, a serous synovitis or hydrops may occur, chiefly in the knee, on one or on both sides.

The Affections of the Eyes, although fortunately rare, are of great importance because of the serious results which may follow if they are not recognised and treated. *Iritis* is the commonest of these, and may occur in one or in both eyes, one after the other, from three to eight months after infection. The patient complains of impairment of sight and of frontal or supraorbital pain. The eye waters and is hypersensitive, the iris is discoloured and reacts sluggishly to light, and there is a zone of ciliary congestion around the cornea. The appearance of minute white nodules or flakes of lymph at the margin of the pupil is especially characteristic of syphilitic iritis. When adhesions have formed between the iris and the structures in relation to it, the pupil dilates irregularly under atropin. Although complete recovery is to be expected under early and energetic treatment, if neglected, *iritis* may result in occlusion of the pupil and permanent impairment or loss of sight.

The other lesions of the eye are much rarer, and can only be discovered on ophthalmoscopic examination. *Choroiditis* occurs in patches, and leaves areas of a white or grey colour surrounded by black pigment. Unless these patches occur in the vicinity of the optic disc, they give rise to no symptoms. *Neuro-retinitis*, on the other hand, attracts attention because it is attended with failure of sight in one or in both eyes; the optic disc and adjacent retina present the usual appearances of inflammation, becoming blurred and hazy.

The virus of syphilis exerts a special influence upon the *Blood-vessels*, exciting a proliferation of the endothelial lining which results in narrowing of their lumen, *endarteritis*, and a perivascular infiltration in the form of accumulations of plasma cells around the vessels and in the lymphatics that accompany them.

In the *Brain*, in the later periods of secondary and in tertiary syphilis, changes occur as a result of the narrowing of the lumen of the arteries, or of their complete obliteration by thrombosis. By interfering with the nutrition of

those parts of the brain supplied by the affected arteries, these lesions give rise to clinical features of which severe headache and paralysis are the most prominent. The paralysis may involve one side of the body (hemiplegia), and be attended with convulsions and coma, or may be confined to one limb or to the area of distribution of certain of the cranial nerves. Anti-syphilitic remedies have but little curative influence in these lesions, and the paralysis is often permanent.

Affections of the *Spinal Cord* are extremely rare, but paraplegia from myelitis has been observed.

Lastly, attention must be directed to the remarkable variations observed in different patients, not only when the disease is allowed to run its course without treatment, but also when anti-syphilitic remedies have been employed. Sometimes the virulent character of the disease can only be accounted for by an idiosyncrasy of the patient. Constitutional symptoms, particularly pyrexia and anæmia, are most often met with in young women. Patients over forty years of age have greater difficulty in overcoming the infection than younger adults. Malarial and other fevers, and the conditions attending life in tropical countries, from the debility which they cause, tend to aggravate and prolong the disease, which then assumes the characters of what has been called *malignant syphilis*. All chronic ailments have a similar influence, and alcoholic intemperance is universally regarded as a serious aggravating factor. It is a popular belief that syphilis acquired in certain countries is of a specially virulent type, but if the factors to which reference has just been made are eliminated, there remains no evidence to support such a belief. It would appear to be rather a question of the resistance of the individual than of the virulence of the infecting agent. These considerations have an important bearing on the treatment of the disease.

Diagnosis of Secondary Syphilis.—A routine examination should be made of the parts of the body which are most often affected in this disease—the scalp, mouth, throat, posterior cervical glands, and the trunk, the patient being stripped and examined by daylight. Among the *diagnostic features of the skin affections* the following may be mentioned:—They are frequently, and sometimes to a marked degree, symmetrical; more than one type of eruption—papules and pustules, for example—may be present at the same time; there is little itching; they are at first a dull-red colour, but later present

a brown pigmentation which has been likened to the colour of raw ham; they exhibit a predilection for those parts of the forehead and neck which are close to the roots of the hair; they tend to pass off spontaneously; and they disappear rapidly under the influence of mercury.

Serum Diagnosis — Wassermann Reaction. — “There is general agreement amongst workers on the subject that this test affords by far the most reliable means of diagnosing the disease; and on comparing the results obtained it will not be an overestimate to say that a positive result may be obtained in at least 90 per cent. of cases where there is evidence of active general infection. The reaction generally appears first on the fifteenth to the thirtieth day after the appearance of the sore, and then gradually becomes more marked; during the period of secondary manifestations it is practically always present; in the tertiary stage with active manifestations a positive result is only a little less frequent. As the disease becomes inactive or is cured the reaction may disappear, but it is to be noted that disappearance of the reaction after being present does not necessarily imply cure of the disease. The disease may only have become latent, and on its becoming once more active the reaction may re-appear. Energetic treatment with mercury may also diminish or annul the reaction; in fact its presence and intensity would appear to be definitely related to the activity of the syphilitic lesions. A positive reaction is also present in a large majority of cases of general paralysis and of tabes, and may be given by the cerebro-spinal fluid as well as by the blood serum. As regards other diseases, a positive reaction has been recorded as occurring in leprosy and sleeping-sickness and also in yaws, but apart from these diseases it is practically never met with.”¹

Treatment of Secondary Syphilis.—In the treatment of syphilis the two main objects are to maintain the general health at the highest possible standard, and to introduce into the system therapeutic agents which will inhibit or destroy the invading parasite.

The General Health.—The patient must lead a regular life and cultivate the fresh-air habit, which is as beneficial in syphilis as in tuberculosis. Anæmia, malaria, and other sources of debility must receive appropriate treatment. The diet should be simple and easily digested, and should include a full supply of milk. Alcohol is prohibited unless it is required as a food, in which case beer, claret, or stout may be allowed at meals.

¹ *Manual of Bacteriology*, Muir and Ritchie, 5th edition, 1911.

The excretory organs are encouraged to act by the liberal drinking of hot water between meals, say five or six tumblerfuls in the twenty-four hours. The functions of the skin are further aided by frequent hot baths, and by the wearing of warm under-clothing. While the patient should avoid exposure to cold, and taxing his energies by undue exertion, he should be advised to take exercise in the open air. On account of the liability to lesions of the mouth and throat, he should use tobacco in moderation, his teeth should be thoroughly overhauled by the dentist, and he should brush them after every meal, using an antiseptic tooth powder or wash. The mouth and throat should be rinsed out night and morning with a solution of chlorate of potash and alum, or with peroxide of hydrogen.

The Administration of Mercury.—As soon as the diagnosis is established, the patient should be brought under the influence of mercury. The amount of mercury to be given in any case must be proportioned to the idiosyncrasies of the patient, and it is advisable, before commencing the treatment, to test his urine and record his body-weight. The small amount of mercury given at the outset is gradually increased until there appears a trace of soreness of the gums; it is then diminished so as just to fall short of producing this effect. Having thus discovered the proper dose for the individual, it should be continued for two years unless any contra-indication develops. If the body-weight falls, or if the gums become sore and the breath foul, the mercury should be stopped for a time. If salivation occurs, the drinking of hot water and the taking of hot baths should be insisted upon, and half-dram doses of the alkaline sulphates prescribed.

Methods of Administering Mercury.—(1) *By the Mouth.*—This has long been the most popular method in this country, the preparation usually employed being grey powder, in pills or tablets, each of which contains one grain of the powder. Three of these are given daily in the first instance, and the daily dose is increased to five or even seven grains till the standard for the individual patient is arrived at. As the grey powder alone sometimes causes irritation of the bowels, it should be combined with iron, as in the following formula:—Hydrarg. c. cret. gr. 1; ferri sulph. exsicc. gr. 1 or 2.

When the grey powder fails to relieve or does not agree with the patient, some other preparation may be substituted, such as the green iodide of mercury, in doses of quarter or half a grain, gradually raised to one grain three times a day: or the liquor of the perchloride of mercury in dram doses.

(2) *By Inunction.*—Inunction consists in rubbing into the pores of the skin an ointment composed of equal parts of 20 per cent. oleate of mercury and lanolin. Every night after a hot bath, a dram of the ointment (made up by the chemist in paper packets) is rubbed for fifteen minutes into the skin where it is soft and comparatively free from hairs. Different parts of the body should be selected in rotation, and scrupulous cleanliness observed so as to avoid septic irritation of the skin. The underclothing becomes impregnated with mercury, and, as it cannot be washed, must be thrown away when soiled. Inunction is undoubtedly troublesome, but is by far the most efficient method of bringing the patient rapidly under the influence of mercury, and it is therefore specially valuable in syphilis where time has already been lost and the patient first seeks advice for an iritis or other late lesion. It is also of value in cases of cerebral syphilis, in syphilis appearing after marriage, and in cases in which the symptoms persist in spite of the administration of mercury by the mouth. When the patient has been brought under the influence of the mercury, inunction may be replaced by one of the other methods of administering the drug.

(3) *By Intramuscular Injection.*—This consists in introducing the drug by means of a hypodermic syringe into the substance of the gluteal muscles. The skin of the patient, the preparation employed, and the instrument must be sterilised. The syringe is made of glass, and has a solid glass piston; the needle of platino-iridium should be 5 cm. long and of a larger calibre than the ordinary hypodermic needle. The preparation usually employed consists of: metallic mercury or calomel one dram, lanolin and olive oil each two drams; it must be warmed to allow of its passage through the needle. Five minims—containing one grain of metallic mercury—represent a dose, and this is injected into the muscles above and behind the great trochanter once a week. The contents of the syringe are slowly expressed, and, after withdrawing the needle, gentle massage of the buttock should be employed. Four courses each of ten injections are given the first year, three courses of the same number during the second and third years, and two courses during the fourth year (Lambkin). This method has been found specially useful by naval and military surgeons who cannot rely on the men taking pills, and as the injection is only made at intervals the patient need not be admitted to hospital; unless, however, the dose is regulated with great accuracy, mercurial poisoning may result, with, it may be,

serious consequences. We have used the method in the Lock Wards of the Royal Infirmary, and have been satisfied with the results obtained; it is, however, inferior to inunction in the rapidity with which the patient is mercurialised.

Iodides in Secondary Syphilis.—While generally recognised as being of little use at the beginning of the secondary stage, iodides are of value in the treatment of the later manifestations, especially those which approach in character the lesions of the tertiary period and do not yield to mercury alone, such as the deeper lesions in the skin and throat, and in the nervous system. The iodide of potassium or sodium is given in five to fifteen grain doses thrice daily, either in solution along with the bichloride of mercury, or separately in the form of tablets. When iodides are given after the completion of a course of mercury, their effects must be watched, as the iodides liberate mercury which has accumulated in an insoluble form in the tissues, and salivation may result. Two years having been devoted to the continuous administration of mercury, combined with iodides during the last three months of the second year, both remedies should be given during one month in the middle of the third and of the fourth years.

In cases with marked debility and cachexia, in which mercury and iodides have failed to give relief or appear even to have aggravated the disease (and this is most often the case in patients who have resided in tropical countries), a trial should be given to sarsaparilla taken in large quantities of hot water. One of the best-known preparations is *Zittmann's decoction*, but the more easily obtained concentrated compound decoction of sarsaparilla, in doses of half or one ounce well diluted with hot water, taken several times a day for two or three weeks, is quite as efficacious. We can bear out the statement that it sometimes acts like a charm when all other treatment has failed.

Salvarsan.—After patient research, the object of which was to determine the elective affinities of certain chemical substances towards various organic tissues, Ehrlich discovered the elective action of arsenical compounds upon various spirilla. The direct result of this was that in conjunction with his pupil, Hata, he built up the compound dioxy-diamido-arseno-benzol, popularly known as salvarsan or "606," which is already established as far more powerful than any of the therapeutic agents which have hitherto been used in the treatment of syphilis. It is a yellowish powder and is supplied in sealed glass tubes, each containing the average adult dose of .6 gram.

The powder is dissolved immediately before use under aseptic conditions by a skilled chemist; the resulting solution is then injected deeply into the gluteal muscles or is introduced into a vein. The intramuscular injection is usually followed by a good deal of pain, sometimes by a disability of the limb on the same side, and occasionally by sloughing of the tissues. Whenever possible, therefore, the intravenous method should be preferred; the drug, freely diluted with warm saline solution, is allowed to run slowly, by gravitation, into the left median basilic or other accessible vein. As a rule the patient feels sick, chilly, and depressed some six to ten hours after the administration, and he should be strongly advised to keep his bed for two or three days.

The manifestations of the disease, whether primary, secondary, or tertiary, usually disappear with remarkable rapidity, and the same holds true in cases which have resisted mercurial treatment. Observations show that the spirochaetes lose their capacity for movement within an hour or two of the administration, and usually disappear altogether in from twenty-four to thirty-six hours. Wassermann's reaction usually yields a negative result in from three weeks to two months, but later may again become positive. A second dose of salvarsan is therefore usually indicated. It is not known at present whether the mercurial course should be prescribed in addition to treatment by salvarsan. In the meantime it would appear safer to carry out both methods.

It need scarcely be pointed out that the general use of so powerful a drug as salvarsan is not likely to be free from risk; it may be mentioned that each dose contains nearly three grains of arsenic. Before administering salvarsan the patient must be thoroughly overhauled; its administration is absolutely contra-indicated in the presence of disease of the heart and blood-vessels, especially a combination of syphilitic aortitis and sclerosis of the coronary arteries, with degeneration of the heart muscle; in cases of extensive diffuse affections of the central nervous system, especially advanced paralysis, and in such severe disturbances of metabolism as are associated with diabetes and Bright's disease.

Treatment of the Local Manifestations.—The skin lesions are treated on the same lines as similar eruptions of other origin. As local applications, preparations of mercury are usually selected, notably the ointments of the red oxide of mercury, ammoniated mercury, or oleate of mercury (5 per cent.), or the mercurial plaster introduced by Unna. In the treatment of condylomata the greatest attention must be paid to cleanliness

and dryness. After washing and drying the affected patches, they are dusted with a powder consisting of equal parts of calomel and carbonate of zinc; and apposed skin surfaces, such as the nates or labia, are separated by sublimate wool. In the ulcers of later secondary syphilis, crusts are got rid of in the first instance by means of a boracic poultice, after which a piece of lint or gauze cut to the size of the ulcer and soaked in black wash is applied and covered with oil-silk. If the ulcer tends to spread in area or in depth, it should be scraped with a sharp spoon, and painted over with acid nitrate of mercury, or a hyperæmia may be induced by Klapp's suction apparatus.

In lesions of the mouth and throat, the teeth should be attended to; the best local application is a solution of chromic acid—ten grains to the ounce—painted on with a brush once daily. If this fails, the lesions may be dusted with calomel the last thing at night. For deep ulcers of the throat the patient should gargle frequently with chlorine water or with perchloride of mercury (1 in 2000); if the ulcer continues to spread it should be painted with acid nitrate of mercury.

In the treatment of *iritis* the eyes are shaded from the light and completely rested, and the pupil is well dilated by atropin to prevent adhesions. If there is much pain, a blister may be applied to the temple.

The Relations of Syphilis to Marriage.—Before the introduction of the Ehrlich-Hata treatment no patient was allowed to marry until three years had elapsed after the disappearance of the last manifestation. While marriage might be entered upon under these conditions without risk of the husband infecting the wife, the possibility of his conveying the disease to the offspring could not be absolutely excluded. It is recommended as a precautionary measure, to give a further mercurial course of two or three months' duration before marriage, or its modern equivalent, an intravenous injection of salvarsan.

Intermediate Stage.—After the dying away of the secondary manifestations and before the appearance of tertiary lesions, the patient may present certain symptoms which Hutchinson has called *reminders*. These usually consist of relapses of certain of the affections of the skin, mouth, or throat, already described. In the skin, they may assume the form of peeling patches in the palms, or may appear as spreading and confluent circles of a scaly papular eruption, which if neglected may lead to the formation of fissures and superficial ulcers. Less frequently there is a relapse of the eye affections, or of paralytic symptoms from disease of the cerebral arteries.

Treatment is conducted on the same lines as in secondary syphilis.

Tertiary Syphilis.—While the manifestations of primary and secondary syphilis are common, those of the tertiary period are by comparison rare, and are observed chiefly in those who have either neglected treatment or who have had their powers of resistance lowered by privation, by alcoholic indulgence, or by tropical disease.

The *general characters of tertiary manifestations* may be stated as follows. They attack by preference the tissues derived from the mesoblastic layer of the embryo—the cellular tissue, bones, muscles, and viscera. They are often localised to one particular tissue or organ, such, for example, as the subcutaneous cellular tissue, the bones, or the liver, and they are rarely symmetrical. They are usually aggressive and persistent, with little tendency to natural cure, and they may be dangerous to life, because of the destructive changes produced in such organs as the brain or the larynx. They are remarkably amenable to treatment by iodides, if these are given before the stage which is attended with destruction of tissue is reached. Early tertiary lesions may be infective and the disease may be transmitted by the discharges from them; but the later the lesions the less is the risk of their containing an infective virus.



FIG. 40.—Ulcerating Gumma of Lips.
(From a photograph lent by Dr. Stopford Taylor and Dr. R. W. Mackenna.)

The most prominent feature of tertiary syphilis consists in the formation of granulation tissue, and this takes place on a scale considerably larger than that observed in lesions of the secondary period. The granulation tissue frequently forms a definite swelling or tumour-like mass (syphiloma), which, from its peculiar elastic consistence, is known as a *gumma*. In its

early stages a gumma is a firm, semi-translucent greyish or greyish-red mass of tissue; later it becomes opaque, yellow and caseous, with a tendency to soften and liquefy. The gumma does harm by displacing and replacing the normal tissue elements of the part affected, and by involving these in the degenerative changes, of the nature of caseation and necrosis, which produce the destructive lesions of the skin, mucous membranes, and internal organs. This is true not only of the circumscribed gumma, but of the condition known as *gummatous infiltration* or *syphilitic cirrhosis*, in which the granulation tissue is diffused throughout the connective-tissue framework of such organs as the tongue or liver. Both the gummatous lesions and the fibrosis of tertiary syphilis are directly excited by the spirochætes.

The life-history of an untreated gumma varies with its environment. When protected from injury and irritation in the substance of an internal organ such as the liver, it may become encapsulated by fibrous tissue, and persist in this condition for an indefinite period, or it may be absorbed and leave in its place a fibrous cicatrix. In the interior of a long bone it may replace the rigid framework of the shaft to such an extent as to lead to pathological fracture. If it is near the surface of the body—as, for example, in the subcutaneous or submucous cellular tissue, or in the periosteum of a superficial bone, such as the palate, the skull, or the tibia—the tissue of which it is composed is very apt to undergo necrosis, in which the overlying skin or mucous membrane frequently participates, the result being an ulcer—the tertiary syphilitic ulcer (Figs. 20, 40, and 41).

Tertiary Lesions of the Skin and Subcutaneous Cellular Tissue.—The clinical features of a *subcutaneous gumma* are those of an indolent, painless, elastic swelling, varying in size from that of a pea to that of an almond or walnut. After a variable period it usually softens in the centre, the skin over it becomes livid and dusky, and finally separates as a slough, exposing the tissue of the gumma, which sometimes appears as a mucoid, yellowish, honey-like substance; more frequently as a sodden, caseated tissue resembling wash-leather. The caseated tissue of a gumma differs from the corresponding tissue of a tuberculous lesion in being tough and firm, of a buff colour like wash-leather, or whitish, like boiled fish. The degenerated tissue of a gumma separates slowly and gradually, and in untreated cases may be visible for weeks in the floor of the ulcer.

The *tertiary ulcer* may be situated anywhere, but is most frequently met with on the legs, especially in the region of the knee (Fig. 41) and over the calf. There may be one or more ulcers, and also scars of antecedent ulcers. The edges are sharply cut, as if punched out; the margins are rounded in outline, firm, and congested; the base is occupied by gummatous tissue, or, if this has already separated and sloughed out, by unhealthy granulations and a thick purulent



FIG. 41.—Tertiary Syphilitic Ulceration in region of Knee and on both Thumbs of woman æt. 37.

discharge. When the ulcer has healed it leaves a scar which is depressed, and if over a bone, is adherent to it. The features of the tertiary ulcer, however, are not always so characteristic as the above description would imply. It is to be diagnosed from the "leg ulcer," which occurs almost exclusively on the lower third of the leg; from Bazin's disease (p. 82); from the ulcers which result from certain forms of malignant disease, such as rodent cancer, and from those met with in chronic glanders.

Gummatous Infiltration of the Skin ("syphilitic lupus").—

This is a lesion, met with chiefly on the face and in the region of the external genitals, in which the skin becomes infiltrated with granulation tissue so that it is thickened, raised above the surface, and of a brownish-red colour. It appears as isolated nodules, which may fuse together; the epidermis becomes scaly and is shed, giving rise to superficial ulcers which are usually covered by crusted discharge. The disease tends to spread, creeping over the skin with a serpiginous, crescentic, or horse-shoe margin, while the central portion may heal and leave a scar. When untreated, the lesion is persistent and destructive. From the fact of its healing in the centre while it spreads at the margin, it may simulate tuberculous disease of the skin. The syphilitic affection can usually be differentiated by observing that the infiltration of the skin is on a larger scale; the progress of the disease is much more rapid, involving in the course of months an area which in the case of tuberculosis would require as many years; the scars are sounder and are less liable to break down again; and, finally, the disease rapidly yields to anti-syphilitic treatment.

Tertiary lesions of mucous membrane and of the submucous cellular tissue are met with chiefly in the tongue, nose, throat, larynx, and rectum. They originate as gummata or as gummatous infiltrations, which are liable to break down and lead to the formation of ulcers which may prove locally destructive, and, in such situations as the larynx, even dangerous to life. In the tongue the tertiary ulcer may prove the starting-point of cancer; and in the larynx or rectum the healing of the ulcer may lead to cicatricial stenosis or stricture.

Tertiary lesions of the *bones and joints*, of the *muscles*, and of the *internal organs*, will be described under these heads. The part played by syphilis in the production of atheroma and of aneurysm will be referred to along with diseases of blood-vessels.

Diagnosis.—From the great diversity in the nature and seat of the lesions met with in tertiary syphilis, it is impossible to lay down general rules for diagnosis, but the student may be cautioned, on the one hand, against relying upon the absence of a history of antecedent syphilis, and, on the other, against diagnosing lesions as syphilitic simply because their origin is obscure. The Wassermann test should be had recourse to whenever possible.

Treatment.—The most valuable drugs for the treatment of the manifestations of the tertiary period are salvarsan and the iodides of sodium and potassium. While iodides are most

effective in promoting the absorption of recent gummata and gummatous infiltrations, they do not remedy the destructive changes brought about by gummata. On account of their depressing effects, they are frequently prescribed along with carbonate of ammonium. The dose is usually a matter of experiment in each individual case; 5 grains three times a day may suffice, or it may be necessary to increase each dose to 20 or 25 grains. The symptoms of iodism which may follow from the smaller doses usually disappear on giving a larger amount of the drug. It should be taken after meals, with abundant water or other fluid, especially if given in tablet form. It is advisable to continue the iodides for from one to three months after the lesions for which they are given have cleared up. If the potassium salt is not tolerated, it may be replaced by the ammonium or sodium iodide. A combination of the perchloride of mercury with iodides is in some cases more efficacious than the iodides alone. A combination of iodine with sesame oil, known as iodipin, is said to be more efficient in some cases than iodides: 30 minims of a 10-25 per cent. solution are given thrice daily in milk two hours after food; or 30 minims of a 25 per cent. solution may be injected hypodermically once a day. The general health should receive the same careful attention as during the secondary period; much assistance is sometimes obtained from sarsaparilla, and from tonics such as arsenic, iron, quinine, and strychnin, from cod-liver oil, and from change of air either by land or sea.

The Local Treatment.—The absorption of a subcutaneous gumma is often hastened by the application of a fly-blister. The incision of a gumma is scarcely ever called for. When a gumma has broken on the surface and caused an ulcer, this is treated on general principles, with a preference, however, for applications containing mercury or iodine, or both. If a wet dressing is required to cleanse the ulcer, black wash may be used; if a powder to promote dryness, one containing iodoform; if an ointment is indicated, the choice lies between the red oxide of mercury or the dilute nitrate of mercury ointment, and one consisting of equal parts of lanolin and vaselin with 2 per cent. of iodine. When there is any spreading tendency in ulcers of the skin or mucous membrane, the surface may be cauterised with the acid nitrate of mercury. Deep ulcers, lesions of the bones, larynx, and other parts which prove obstinate, may be treated by operative measures directed towards the removal of the diseased tissues.

Second attacks of syphilis, although very rare, do occur, especially in those who have been successfully treated. So long as the virus of syphilis remains active in the system, it protects the patient against a second attack. As a rule, therefore, there is an interval of several years before a patient who has had syphilis can contract the disease a second time.

As connected with this subject, we may refer to the **relapsing false indurated chancre**, described by Hutchinson and by Fournier, as it may be the source of difficulty in diagnosis. A patient who has had an infecting chancre one or more years before, presents a slightly raised induration on the penis at or close to the site of his original sore. Often the relapsed induration is so like that of a primary chancre that it is impossible to distinguish it except by the history. If he has lately been exposed to venereal infection, it is liable to be regarded as the primary lesion of a second attack of syphilis, but the further progress shows that neither bullet-buboes nor secondary manifestations develop. These facts, together with the disappearance of the induration under iodides, make it very likely that the lesion is really gummatous in character.

INHERITED SYPHILIS

One of the most striking features of syphilis is that it may be transmitted from parents who have suffered from the disease to their offspring, the children exhibiting the manifestations that characterise the acquired affection.

The more recent the syphilis in either parent the greater is the risk of the disease being communicated to the offspring; so that if either parent suffers from secondary syphilis the infection is almost inevitably transmitted. The capacity of transmitting the disease, however, may be extended after the disappearance of all secondary manifestations.

While it is certain that either parent may be responsible for transmitting the disease to the next generation, the exact method of transmission is not known. In the case of a syphilitic mother, it is most probable that the infection is conveyed to the foetus by the placental circulation. In the case of a syphilitic father, it is commonly believed that the infection is conveyed to the ovum through the seminal fluid at the moment of conception. If a series of children, one after the other, suffer from inherited syphilis, it is almost invariably the case that the mother has herself suffered from syphilis.

In contrast to the acquired form, inherited syphilis is remarkable for the absence of any primary stage, the infection being a general one from the outset, and the infection is much more intense. The spirochæte is demonstrated in incredible numbers in the liver, spleen, lung, and other organs, and in the nasal secretion, and, from any of these, successful inoculations in monkeys are readily made. The manifestations differ in degree rather than in kind from those of the acquired disease; the difference is partly due to the fact that the virus is attacking developing instead of fully formed tissues.

The virus exercises a most injurious influence on the fœtus, which in many cases dies during the early months of intra-uterine life, so that miscarriage results, and this may take place in repeated pregnancies, the date at which the miscarriage occurs becoming later and later as the virus in the mother becomes attenuated. Eventually a child is carried to full term, and it may be still-born, or, if born alive, may suffer from syphilitic manifestations. It has usually been taught that in a family of syphilitic children the elder ones



FIG. 42.—Facies of Inherited Syphilis in a girl æt. 20.

suffer more severely than the younger, because they come nearer to the parental infection, but it would not appear that there is any such variation in severity. It is difficult to explain such vagaries of syphilitic inheritance as the infection of one twin and the escape of the other.

Clinical Features.—We are not here concerned with the severe forms of the disease which soon prove fatal, but with the milder forms in which the infant is apparently healthy when born, but after from two to six weeks begins to show evidence of the syphilitic taint.

The usual phenomena are that the child ceases to thrive, becomes thin and sallow and suffers from eruptions on the skin and mucous membranes. There is frequently a characteristic condition known as *snuffles*, in which the nasal passages are obstructed by an accumulation of thin mucopurulent discharge which causes the breathing to be noisy. It usually begins within a month after birth and before the eruptions on the skin appear. When long continued it is liable to interfere with the development of the nasal bones, so that when the child grows up the bridge of the nose is deficient, the condition being known as the "saddle-nose" deformity (Figs. 42 and 43).



FIG. 43.—Facies of Inherited Syphilis.

(From Dr. Byrom Bramwell's *Atlas of Clinical Medicine*.)

Affections of the Skin.—Although all types of skin affection are met with in the inherited disease, the most important is a *papular* eruption, the papules being of large size, with a smooth shining top and of a reddish-brown colour. It affects chiefly the buttocks and posterior aspect of the thighs, the external genitals, and other parts which are constantly moist. It is necessary to distinguish this specific eruption from a form of eczema which frequently occurs in these situations in non-syphilitic children, the points that characterise the syphilitic condition being the infiltration of the skin and the coppery colour of the eruption. At the angles of the mouth and at the anus the papules acquire the characters of *condylomata*. At the angles of the mouth they often ulcerate and leave fine radiating scars (Fig. 42).

Affections of the Mucous Membranes.—The inflammation of the nasal mucous membrane that causes snuffles has already been referred to. There may be mucous patches in the mouth, or a general inflammation or stomatitis which is of special importance, because it frequently results in interference with the development of the permanent teeth. The mucous membrane of the larynx may be the seat of mucous patches or of catarrh, and as a result the child's cry is hoarse.

Affections of the Bones.—Swellings at the ends of the long

bones, due to inflammation at the epiphysial junctions, are most often observed at the upper end of the humerus and in the bones in the region of the elbow. Partial displacement and mobility at the ossifying junction may be observed. The infant cries when the part is touched; and as it does not move the limb voluntarily, the condition is spoken of as *the pseudo-paralysis of syphilis*. Recovery takes place under anti-syphilitic treatment and immobilisation of the limb.

Diffuse thickening of the shafts of the long bones, due to a deposit of new bone by the periosteum, is sometimes met with.

In the skull, especially of infants who suffer also from rickets, two characteristic conditions may be met with, respectively known as Parrot's nodes or bosses, and craniotabes. *The bosses* (Fig. 44) result from the heaping up of new spongy bone beneath the pericranium, and they may be grouped symmetrically around the anterior fontanelle, or may extend along either

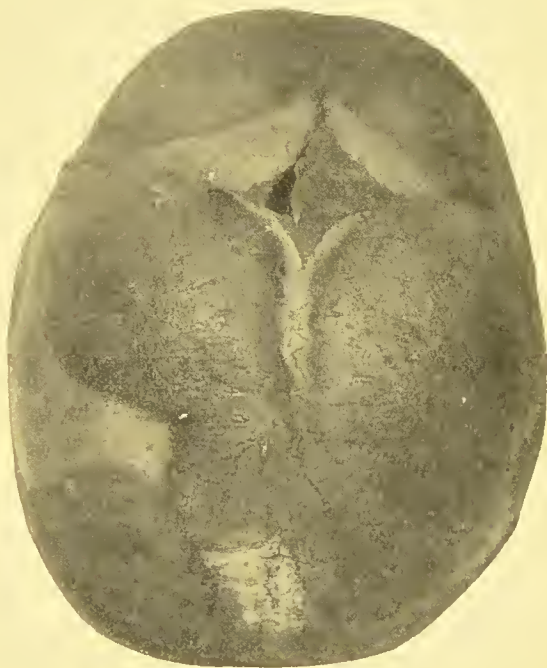


FIG. 44.—Bossing of Skull of Infant in Inherited Syphilis.

side of the sagittal suture, which appears as a deep groove—the “natiform skull.” The bosses disappear in time, but the skull may remain permanently altered in shape, the frontal and parietal eminences often appearing unduly prominent. The term *craniotabes* is applied when the bone becomes thin and soft, reverting to its original membranous condition, so that the affected areas dimple under the finger like parchment or thin cardboard; its localisation in the posterior parts of the skull suggests that the disappearance of the osseous tissue is influenced by the pressure of the head on the pillow.

Craniotabes is entirely recovered from as the child improves in health.

Between the ages of three and six months, certain other phenomena may be met with, such as *effusion into the joints*, especially the knees; *iritis*, in one or in both eyes, and enlargement of the spleen and liver.

In the majority of cases the child recovers from these early manifestations, especially when efficiently treated, and may enjoy an indefinite period of good health. On the other hand, when it attains the age of two to four years, it may begin to manifest lesions which correspond to those of the tertiary period of acquired syphilis. In certain cases the infant fails in health from day to day, its cry is hoarse and feeble, its capacity for sucking diminishes, it becomes emaciated, and dies of exhaustion.

Later Lesions.—In the skin and subcutaneous tissue, the later manifestations may take the form of localised gummata, which tend to break down and form ulcers, on the leg for example, or of a spreading gummatous infiltration which is also liable to ulcerate, leaving disfiguring scars, especially on the face. The palate and fauces may be destroyed by ulceration. In the nose, especially when the ulcerative process is associated with a putrid discharge—*ozæna*—the destruction of tissue may be considerable and result in the most unsightly deformity. The entire palatal portions of the upper jaws, the vomer, turbinate, and other bones bounding the nasal and oral cavities, may ultimately disappear, so that on looking into the mouth the base of the skull is readily seen. Gummatous disease is frequently observed also in the flat bones of the skull, in the bones of the hand, as syphilitic dactylitis, and in the bones of the forearm and leg. When the tibia is affected the disease is frequently bilateral, and may assume the form of gummatous ulcers and sinuses. In later years the tibia may present alterations in shape resulting from antecedent gummatous disease—for example, nodular thickenings of the shaft, flattening of the crest, or a more uniform increase in thickness and length of the entire shaft of the bone, which, when it is curved in addition, is described as the “sabre-blade” deformity. Among lesions of the viscera, mention should be made of gumma of the testis, which causes the organ to become enlarged, uneven, and indurated. This has even been observed in infants a few months old.

Occasionally a syphilitic child suffers from a succession of these gummatous lesions with resulting ill-health, and, it may

be, waxy disease of the internal organs; on the other hand, it may recover and present no further manifestations of the inherited taint.

Affections of the Eyes.—At or near puberty there is frequently observed an affection of the eyes, known as *chronic interstitial keratitis*, the relationship of which to inherited syphilis was first established by Hutchinson. It occurs between the ages of six and sixteen years, and usually affects one eye before the other. It commences as a diffuse haziness or steaminess near the centre of the cornea, and as it spreads the entire cornea assumes the appearance of ground glass. The chief complaint is of dimness of sight which may almost amount to blindness, but there is little pain or photophobia; a certain amount of conjunctival and ciliary congestion is usually present, and there may be *iritis* in addition. The cornea, or parts of it, may become of a deep pink or salmon colour from the formation in it of new blood-vessels. The affection may last for from eighteen months to two years. Complete recovery usually takes place, but slight opacities, especially in the site of former salmon patches, may persist, and the disease occasionally relapses. *Choroiditis* and *retinitis* may also occur, and leave permanent changes easily recognised on examination with the ophthalmoscope.



FIG. 45.—Showing appearance of Permanent Teeth in case of Inherited Syphilis—"Hutchinson's Teeth."

Among the rarer and more serious lesions of the inherited disease may be mentioned gummatous disease in the *larynx* and *trachea*, attended with ulceration and resulting in stenosis; and lesions of the *nervous system* which may result in convulsions, paralysis, or dementia.

In a limited number of cases, about the period of puberty there may develop *deafness*, which is usually bilateral and may become absolute.

Changes in the Permanent Teeth.—These affect specially the upper central incisors, which are dwarfed and stand somewhat apart in the gum, with their free edges converging towards one another. They are tapering or peg-shaped, and present at their cutting margin a deep semilunar notch (Fig. 45). These appearances are commonly associated with the name of Hutchinson, who first described them. Affecting as they do the permanent teeth, they are not available for diagnosis until the child is about eight years of age. Henry Moon drew

attention to a change in the first molars ; these are reduced in size and dome-shaped through dwarfing of the central tubercle of each cusp.

Diagnosis of Inherited Syphilis.—When there is a typical eruption on the buttocks and snuffles there is no difficulty in recognising the disease. When, however, the rash is scanty or is obscured by co-existing eczema, most reliance should be placed on the distribution of the eruption, on the brown stains which are left after it has passed off, on the presence of condylomata, and of fissuring and scarring at the angles of the mouth. The history of the mother relative to repeated miscarriages and still-born children may afford confirmatory evidence. In doubtful cases, the diagnosis may be aided by the Wassermann test and by noting the therapeutic effects of grey powder, which, in syphilitic infants, usually effects a marked and rapid improvement both in the symptoms and in the general health.

Latent Hereditary Syphilis is that form in which tertiary manifestations appear for the first time in adolescence.

While a considerable number of syphilitic children grow up without showing any trace of their syphilitic inheritance, the majority retain throughout life one or more of the following characteristics, which may therefore be described as *permanent signs of the inherited disease*:—Dwarfing of stature from interference with growth at the epiphysial junctions ; the forehead low and vertical, and the parietal and frontal eminences unduly prominent ; the bridge of the nose sunken and rounded ; radiating scars at the angles of the mouth (Fig. 42) ; perforation or destruction of the hard palate ; Hutchinson's teeth ; opacities of the cornea from antecedent keratitis ; alterations in the fundus oculi from choroiditis ; deafness ; depressed scars or nodes on the bones from previous gummata ; "sabre-blade" or other deformity of the tibiæ.

The Contagiousness of Inherited Syphilis.—In 1837, Colles of Dublin stated his belief that, while a syphilitic infant may convey the disease to a healthy wet nurse, it is incapable of infecting its own mother if nursed by her, even although she may never have shown any symptoms of the disease. This doctrine, which is known as *Colles' law*, is generally accepted in spite of the alleged occurrence of occasional exceptions. The older the child the less risk there is of its communicating the disease to others, until eventually the tendency dies out altogether, as it does in the tertiary period of acquired syphilis. It should be added, however, that the contagiousness of inherited syphilis is denied by some observers, who affirm

that, when syphilitic infants prove contagious, the disease has been really acquired at or soon after birth.

There is general agreement that the subjects of inherited syphilis cannot transmit the disease by inheritance to their offspring, and that, although they very rarely acquire the disease *de novo*, it is possible for them to do so when exposed to infection in the ordinary way.

Prognosis of Inherited Syphilis.—Although inherited syphilis is responsible for a large but apparently diminishing mortality in infancy, the subjects of this disease may grow up to be as strong and healthy as their neighbours. Hutchinson insists on the fact that there is very little bad health in the general community that can be attributed to inherited syphilis.

Treatment.—An infant the subject of inherited syphilis should, if possible, be nursed by its mother, and failing this it should be fed by hand. On the first appearance of syphilitic manifestations it should be brought under the influence of mercury. This is best given as grey powder in half or one grain doses three daily; it may be mixed with powdered sugar, or, if digestive derangements arise, may be combined with bismuth or soda. As a rule the grey powder is remarkably well borne by infants, and if they continue to thrive under it, it should be given for from three to six months after all symptoms have disappeared. If the internal administration of mercury does not suit the infant, it may be replaced by inunction. The dilute oleate of mercury is rubbed into the sides of the chest and abdomen, or is applied on the flannel binder twice or thrice weekly. The local lesions are treated on the same lines as in the acquired disease. The general health should be improved in every possible direction; considerable benefit may be derived from the use of cod-liver oil, and from preparations containing iron and calcium. The gummatous lesions are treated on the same lines as in the acquired disease, but it should be pointed out that in inherited syphilis they are frequently found to be less amenable to the influence of iodides, and dependence must largely be placed on measures calculated to improve the general health. Surgical interference may be required in the destructive gummatous lesions of the nose, throat, larynx, and bones, either with the object of arresting the spread of the disease, or of removing or alleviating the resulting deformities. In children suffering from keratitis, the eyes should be protected from the light by smoked or coloured glasses, and the pupils should be dilated with atropin from time to time, especially in cases complicated with iritis.

Salvarsan would appear to be as beneficial in the inherited as in the acquired disease. In infants at the breast, the salvarsan should be given to the mother; in others, it is administered in the same manner as already described—only in a smaller dose, from 3 to 5 centigrams.

Acquired Syphilis in Infants and Young Children.—When syphilis is met with in infants and young children, it is apt to be taken for granted that the disease has been inherited. It is possible, however, for them to acquire the disease—as, for example, while passing through the maternal passages during birth, through being nursed or kissed by infected women, or through the rite of circumcision. The risk of infection which formerly existed by the arm-to-arm method of vaccination has been abolished by the use of calf lymph.

The clinical features of the acquired disease in infants and young children are very similar to those observed in the adult, with a tendency, however, to be more severe, probably because the disease is often late in being recognised and treated.

CHAPTER XI

TUMOURS¹

Definition—Etiology—General characters of innocent and malignant tumours. CLASSIFICATION OF TUMOURS: I. Connective-tissue tumours: (1) *Innocent*: *Lipoma*, *Xanthoma*, *Chondroma*, *Osteoma*, *Odontoma*, *Fibroma*, *Myxoma*, *Endothelioma*, etc.; (2) *Malignant*: *Sarcoma*—II. Epithelial tumours: (1) *Innocent*: *Papilloma*, *Adenoma*, *Cystic Adenoma*; (2) *Malignant*: *Epithelioma*, *Glandular Cancer*, *Rodent Cancer*, *Melanotic Cancer*—III. Dermoids—IV. Teratomata. Cysts: *Retention*, *Exudation*, *Implantation*, *Parasitic*, *Lymphatic or Scrous*. Ganglion.

A TUMOUR or neoplasm is a localised swelling composed of newly formed tissue which fulfils no physiological function. Tumours tend to grow quite independently of the growth of the body, and there is no natural termination to their growth. They are to be distinguished from such over-growths as are of the nature of simple hypertrophy or local giantism, and also from inflammatory swellings, which usually develop under the influence of a definite cause, have a natural termination, and tend to disappear when the cause ceases to act.

The *etiology of tumours* is imperfectly understood. Various factors, acting either singly or in combination, may be concerned in their development. Certain tumours, for example, are the result of some congenital malformation of the particular tissue from which they take origin. This would appear to be the case in many tumours of blood-vessels (angiomata), of cartilage (chondromata), of bone (osteomata), and of secreting gland tissue (adenomata). The theory that tumours originate from foetal residues or “rests,” is associated with the name of Cohnheim. These rests are supposed to be undifferentiated embryonic cells which remain embedded amongst fully formed tissue elements, and lie dormant until they are excited into active growth and give rise to a tumour. This mode of origin

¹ For the histology of tumours the reader is referred to a text-book of pathology.

is illustrated by the development of dermoids from sequestered portions of the epidermis.

Among the local factors concerned in the development of tumours, reference must be made to the influence of irritation. This is probably an important agent in the causation of many of the tumours met with in the skin and in mucous membranes—for example, cancer of the skin, of the lip, and of the tongue. The part played by an injury is doubtful. It not infrequently happens that the development of a tumour is preceded by an injury of the part in which it grows, but it does not necessarily follow that the injury and the tumour are related as cause and effect. It is possible that an injury may stimulate into active growth undifferentiated tissue elements or “rests,” and so determine the growth of a tumour, or that it may alter the characters of a tumour which already exists, causing it to grow more rapidly.

The popular belief that there is some constitutional peculiarity concerned in the causation of tumours is largely based on the fact that certain forms of new growth—for example, cancer—are known to occur with undue frequency in certain families. The same influence is more striking in the case of certain innocent tumours—particularly multiple osteomata and lipomata—which are hereditary in the same sense as supernumerary or webbed fingers, and which may appear in members of the same family through several generations.

INNOCENT AND MALIGNANT TUMOURS

For clinical purposes, tumours are arbitrarily divided into two classes—the innocent and the malignant. The outstanding difference between them is, that while the evil effects of innocent tumours are merely local and depend for their severity on the environment of the growth, malignant tumours wherever situated, in addition to producing local effects, injure the general health of the patient and ultimately cause his death.

Innocent, benign, or simple tumours present a close structural resemblance to the normal tissues of the body. They grow slowly, and are usually definitely circumscribed by a fibrous capsule. They are easily enucleated from their capsule, and do not tend to recur after removal. In their growth they merely push aside and compress adjacent parts, and they present no tendency to ulcerate and bleed unless the overlying skin or mucous membrane is injured. They form no attachment to adjacent parts except as a result of inflammation. Although

usually solitary, some of them may be multiple from the outset—for example, fatty, fibrous, and bony tumours, warts, and fibroid tumours of the uterus. They produce no constitutional disturbance, wasting, or cachexia. They only threaten life when growing in the vicinity of vital organs, and there merely in virtue of their situation—for example, death may result from an innocent tumour in the air-passages causing suffocation, in the intestine causing obstruction of the bowels, or in the vertebral canal causing pressure on the spinal cord.

Malignant tumours usually show a marked departure from the structure and arrangement of the normal tissues of the body. Although the cells of which they are composed are derived from normal tissue cells, in their development they tend to take on a lower, more vegetative form; they may be regarded as parasites living at the cost of the organism, multiplying indefinitely and destroying everything with which they come in contact.

Malignant tumours grow more rapidly than innocent tumours, and tend to infiltrate their surroundings by sending out prolongations or offshoots into the surrounding tissues; they are therefore liable to recur after an operation which is restricted to the removal of the main tumour. They are not encapsulated, although they may appear to be circumscribed by condensation of the surrounding tissues; they are rarely multiple at the outset, but show a marked tendency to spread to other parts of the body. Fragments of the parent tumour may become separated and be carried off in the lymph or blood-stream and deposited in other parts of the body, where they give rise to secondary growths. Malignant tumours tend to invade and destroy the overlying skin or mucous membrane, and thus give rise to bleeding ulcers; if the tumour tissue protrudes through the gap in the skin, it is said to *fungate*. They give rise to a condition of general ill-health or *cachexia*, the patient becoming pale, sallow, feverish, and emaciated, probably as a result of chronic poisoning from the absorption of toxic products from the tumour. They ultimately destroy life, it may be by their local effects, such as ulceration and hæmorrhage, by favouring the entrance of septic infection, by interfering with the function of organs which are essential to life, by cachexia, or by a combination of these effects.

The situation of a malignant tumour exercises considerable influence on the rapidity, as well as on the mode, in which it causes death. Some cancers, such as that known as “rodent,” show malignant features which are entirely local, while others,

such as melanotic cancer, exhibit a malignancy characterised by a rapid generalisation of tumour growths throughout the body. Tumours which are structurally alike may show variations in malignancy, not only according to their situation, but also according to the age of the patient and to other factors which are as yet unknown.

In attempting to arrive at a conclusion as to the innocence or malignancy of any tumour, too much reliance must not be placed on its histological features; its situation, rate of growth, and other clinical features must also be taken into consideration. It cannot be too emphatically stated that there is no hard and fast line between innocent and malignant growths; there is an indefinite transition from one to the other. The possibility of the transformation of a benign into a malignant tumour must be admitted. Such a transformation implies a change in the structure of the growth, and has been observed especially in fibrous and cartilaginous tumours, in tumours of the thyroid gland, and in uterine fibroids. The alteration in character may take place under the influence of injury, prolonged or repeated irritation, incomplete removal of the benign tumour, or the altered physiological conditions of the tissues which attend advancing years.

When a tumour is removed by operation it should be subjected to microscopical examination as a routine measure.

Varieties of Tumours.—In the following description, tumours are classified on an anatomical basis, taking in order first the connective-tissue group and subsequently those which originate in epithelium.

INNOCENT CONNECTIVE-TISSUE TUMOURS

Lipoma.—A lipoma is a tumour composed of fat resembling that normally present in the body. The commonest variety is the *subcutaneous lipoma*, which grows from the subcutaneous fat, and forms a soft, irregularly lobulated tumour (Fig. 46). The fat is arranged in lobules separated by connective-tissue septa which are continuous with the capsule surrounding the tumour, and with the overlying skin, which becomes dimpled or puckered when an attempt is made to pinch it up. As the fat is almost fluid at the body temperature, fluctuation can usually be detected in the swelling. These tumours vary greatly in size, occur at all ages, grow very slowly, and, while generally solitary, are sometimes multiple. They are most commonly met with on the shoulder, buttock, or back. In certain situa-

tions, such as the thigh and perineum, they tend to become pedunculated.

A fatty tumour is to be diagnosed from a cold abscess and from a cyst. The distinguishing features of the lipoma are the tacking down and dimpling of the overlying skin, and the lobulation of the tumour, which is recognised when it is pressed upon with the flat of the hand.

The treatment consists in dividing the skin and capsule over the tumour and shelling it out. Care must be taken that none of the outlying lobules are detached and left behind. If



FIG. 46.—Subcutaneous Lipoma showing lobulation.

the overlying skin is closely adherent, it should be removed along with the tumour.

Multiple subcutaneous lipomata are frequently symmetrical, and in a certain group of cases, met with chiefly in women, pain is a prominent symptom, hence the term *adiposis dolorosa* (Dereum).

In the neck, axilla, pubic region and elsewhere, a diffuse overgrowth of the subcutaneous fat is sometimes met with, forming large symmetrical tumour-like masses, known as *diffuse lipoma*. As this is not, strictly speaking, a tumour, the term *diffuse lipomatosis* is to be preferred. A similar condition has been described by Sir Jonathan Hutchinson as being met with

in some of the domestic animals. If causing disfigurement the swelling may be removed, but complete extirpation is usually impossible, as the mass is not encapsulated (Fig. 47).

Lipomata in other situations.—The *periosteal lipoma* is usually of congenital origin, and is most often met with in the hand; it forms a projecting lobulated tumour, which, when situated in the palm, may resemble an angioma or a lymphangioma. The *subserous lipoma* may arise from the extra-peritoneal fat in the posterior abdominal wall, in which case it tends to grow forwards between the layers of the mesentery



FIG. 47.—Diffuse Lipomatosis of Neck.

and to give rise to a large abdominal tumour; or it may grow from the extra-peritoneal fat in the anterior abdominal wall and protrude from one of the normal openings or through an abnormal opening in the parietes, constituting a *fatty hernia*. *Subsynovial lipomata* grow from the fat surrounding the synovial membrane of a joint, and may project into its interior and give rise to the symptoms of loose body. Lipomata are also met with growing from the adipose connective tissue *between or in the substance of muscles*, and, when situated beneath the deep fasciae, the characteristic signs are obscured and a differential diagnosis may be difficult or impossible. It

may be differentiated from a cold abscess by puncture with an exploring needle.

Xanthoma.—A xanthoma is composed of connective-tissue cells containing a granular yellow pigment. It occurs in the skin, especially of the eyelids, in the form of raised yellow patches, which tend to increase in size and fuse with one another. It is occasionally met with in other parts of the

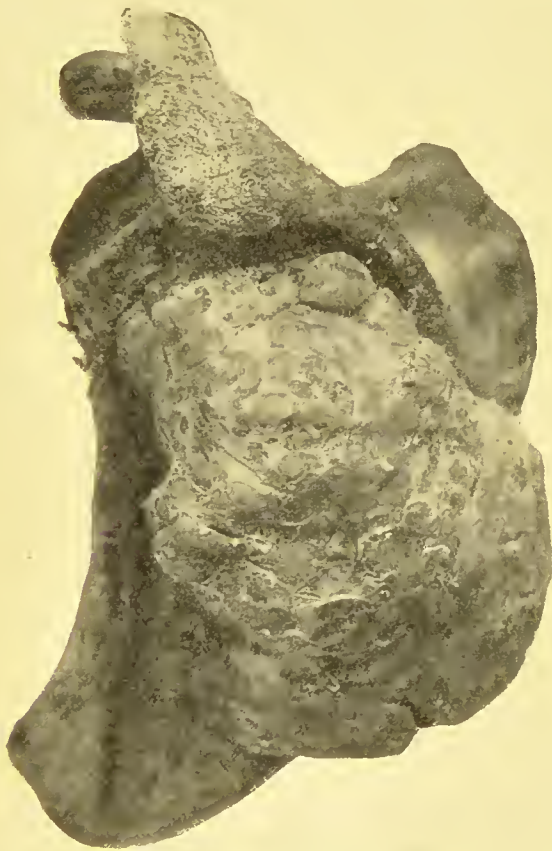


FIG. 48.—Chondroma growing from infra-spinous fossa of Scapula.

body, forming a definite tumour, involving the skin and the underlying soft parts; the tumour tissue is soft in consistence, and on section presents a brilliant orange or saffron colour.

Xanthoma may affect several generations of the same family. When it develops after puberty, it is nearly always associated with chronic jaundice. The tumour-like form of xanthoma may become disseminated throughout the body after the manner of sarcoma.

Chondroma (Fig. 48).—A chondroma is a tumour mainly composed of cartilage. Processes of vascular connective tissue pass in between the nodules of cartilage composing the tumour from the fibrous capsule which surrounds it. On section it is usually of a greyish-blue colour and semi-translucent. The tumour is firm and elastic in consistence, but certain portions may be as hard as bone from calcification or ossification, while other portions may be soft and fluctuating as a result of myxomatous degeneration and liquefaction. These tumours



FIG. 49.—Chondroma of Metacarpal Bone of Thumb.

grow slowly and painlessly, and in the course of their growth may surround nerves and arteries without injuring them. They may cause a deep hollow in the bone from which they originate. All intermediate forms between the innocent chondroma and the malignant chondro-sarcoma are met with. Chondromata may occur in a multiple form, especially in relation to the phalanges and metacarpal bones, and are figured with the Diseases of Bone. When growing in the interior of a bone a chondroma causes a spindle-shaped enlargement of its shaft, which in the case of a phalanx or metacarpal

bone may resemble tuberculous or syphilitic disease of the bone (dactylitis). A chondroma appears as a clear area in a skiagram; when it has undergone calcification or ossification, it gives a shadow as dark or darker than bone.

Treatment.—In those projecting from the surface of a bone, both the tumour and its capsule should be removed. If in the interior, a sufficient amount of the cortex should be removed to allow of the tumour being scraped out, and care must be taken that no nodules of cartilage are left behind. In multiple chondromata of the hand, when the fingers are crippled and useless, the question of amputation may have to be considered. When a cartilaginous tumour takes on active growth, it must be treated as malignant.

The chondromata that are met with at the ends of the long bones in children and young adults form a group by themselves. They are usually related to the epiphysial cartilage, and it was suggested by Virchow that they take origin from unaltered islands of cartilage in the interior of the bone which have not been used up in the process of ossification. They are believed to occur most frequently in those who have suffered from rickets in early life. They tend to undergo ossification concurrently with the epiphysial cartilage from which they take origin, and constitute what are known as *cartilaginous exostoses*. These are sometimes met with in a multiple form, and may occur in several generations of the same family.

Cartilaginous tumours in the parotid, submaxillary gland, or testicle are usually chondro-sarcomata.

Osteoma—An osteoma is a tumour composed of bony tissue, and originating from the skeleton. Two varieties are recognised—the spongy or cancellous, and the ivory or compact. The common *spongy* or *cancellous osteoma* is really an ossified chondroma, and is met with chiefly at the ends of the long bones of the limbs (Fig. 50). From the fact that it projects from the surface of the bone it is often spoken of as an *exostosis*. It grows very slowly, and rarely causes any discomfort unless it presses upon a nerve-trunk or upon an inflamed bursa which has developed over it. The Röntgen rays show a dark shadow corresponding to the ossified portion of the tumour, and continuous with that of the bone from which it is growing. Operative interference is only indicated when the tumour is giving rise to inconvenience. It is then removed, its base or neck being divided by means of the chisel.

The bony outgrowth from the terminal phalanx of the great toe—known as the *subungual exostosis*,—is described and

figured on p. 404. Bony projections or "spurs" sometimes occur on the under surface of the os calcis, and, projecting downwards and forwards from the greater process, may cause pain on putting the heel to the ground.

The *ivory* or *compact osteoma* is composed of dense, compact bone, and usually grows from the skull. It is generally sessile and solitary, and may grow into the interior of the skull, into the frontal sinus, into the cavity of the orbit or nose, or may fill up the external auditory meatus.

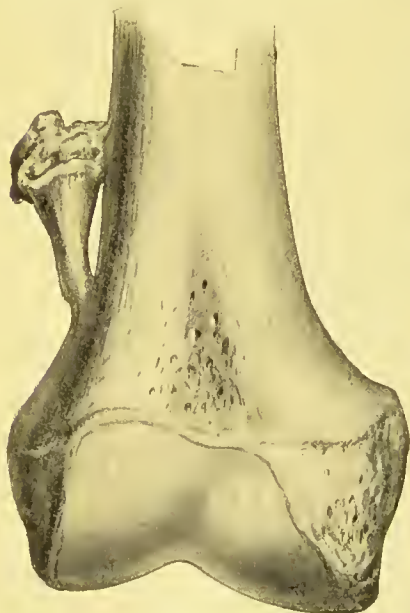


FIG. 50.—Cancellous Osteoma of lower end of Femur.

Bony formations sometimes occur in *muscles and tendons*, especially at their points of attachment to the skeleton, and are described with the diseases of muscles.

Odontoma.—An odontoma is a tumour composed of dental tissues in varying proportions and different degrees of development, arising from tooth-germs or from teeth still in process of growth (Bland Sutton). Odontomata resemble teeth in so far that during their development they remain hidden below the mucous membrane and give no evidence of their existence. There then succeeds, usually between the twentieth and twenty-fifth years, an eruptive stage,

which is often attended with suppuration, and this may be the means of drawing attention to the tumour. Following Bland Sutton, we may distinguish several varieties of odontoma according to the part of the tooth-germ concerned in their formation.

Epithelial odontomata are derived from persistent portions of the epithelium of the enamel organ, and constitute multilocular cystic tumours which are chiefly met with in the lower jaw. The cystic spaces of the tumour contain a brownish glairy fluid. These tumours have been described by Eve under the name of multilocular cystic epithelial tumours of the jaw.

The *follicular odontoma*, formerly known as a *dentigerous cyst*, is derived from the distension of a tooth follicle. It constitutes a cyst which contains a viscid fluid, and an imperfectly formed tooth is often found embedded in its wall. The cyst usually forms in relation to one of the permanent molars, and may attain considerable dimensions.

The *fibrous odontoma* is the result of an overgrowth of fibrous tissue surrounding the tooth sac, which encapsulates the tooth and prevents its eruption. The thickened tooth sac is usually mistaken for a fibrous tumour, until the tooth is recognised in its interior after removal.

Composite Odontomata.—This is a convenient term to apply to certain hard dental tumours which are met with in the jaws, and consist of enamel, dentine, and cement. They are to be regarded as being derived from an abnormal growth of all the elements of a tooth germ, or of two or more tooth germs, indiscriminately fused with one another. They may appear in childhood, and form smooth unyielding tumours, often of considerable size, replacing the corresponding permanent teeth. Many examples of this variety of odontoma, growing in the nasal cavity or in the antrum, have been erroneously regarded as osteomata even after removal. They may cause a purulent discharge, and in some cases have been spontaneously extruded after sloughing of the overlying soft parts.

On section, the tumour is usually laminated, and is seen to consist mainly of dentine with a partial covering of enamel and cement.

Diagnosis.—Odontomata are often only diagnosed after removal. When attended with suppuration, the condition has been mistaken for disease of the jaw. Fibrous odontomata have been mistaken for sarcomata, and portions of the maxilla removed unnecessarily. Any circumscribed tumour of the jaw, particularly when met with in a young adult, should suggest the possibility of an odontoma.

Treatment.—The solid varieties of odontoma can usually be shelled out after dividing the overlying soft parts. In the follicular variety, it is usually sufficient to excise a portion of the wall, scrape out the interior, and remove any tooth that may be present. The cavity is then packed with gauze, and allowed to heal from the bottom.

Fibroma.—A fibroma is a tumour composed of fibrous connective tissue. A distinction may be made between the *soft fibroma*, which is comparatively rich in cells and blood-

vessels, and in which the fibres are arranged loosely; and the *hard fibroma*, which is almost entirely composed of closely packed bundles of fibres often arranged in a concentric fashion around the blood-vessels. The cut surface of the soft fibroma presents a pinkish-white, fleshy appearance resembling the slowly growing forms of sarcoma; that of a hard fibroma presents a dry, glistening appearance, aptly compared to watered silk. The soft variety grows much more rapidly than the hard. In certain fibromata—in those, for example, which grow from the periosteum of the base of the skull and project into the naso-pharynx—the blood-vessels are dilated into sinuses and have no proper sheaths; they therefore tend to remain open when divided, and to bleed excessively. Transition forms between soft fibromata and sarcomata are met with, so that in operating for their removal it is safer to take away the capsule along with the tumour, and the patient should be kept under observation in view of the risk of recurrence.

The skin—especially the skin of the buttock—is one of the favourite seats of fibromata, and they may occur in a multiple form. They are met with also in the subcutaneous and intermuscular cellular tissue, and in the abdominal wall, where they sometimes attain considerable dimensions. The fibrous overgrowths in the skin, known as *keloid* and *molluscum fibrosum*, and those met with in the *sheaths of nerves*, are described elsewhere. Fibroid tumours of the uterus are described with myomata.

Diffuse fibroma or *Fibromatosis*, analogous to lipomatosis, is met with in the connective tissue of the skin and sheaths of nerves, and constitutes one form of neuro-fibromatosis; a similar change is also met with in the stomach and intestines.

Myxoma.—A myxoma is composed of tissue similar to that found in the umbilical cord. The tumour is characterised by its soft, gelatinous, semifluid consistence. The pure myxoma is extremely rare, and occurring, as it does, chiefly in the subcutaneous and intermuscular connective tissue, it resembles clinically the lipoma. Myxomatous tissue is, however, frequently found in other connective-tissue tumours as a result of myxomatous degeneration. This is specially observed in cartilaginous tumours and in sarcomata. Myxomatous tissue is usually a prominent constituent of the “innocent parotid tumour.” Mucous polypi of the nose, which are often described as myxomata, are merely pendulous processes of œdematous mucous membrane.

Myeloma.—A myeloma is a tumour composed of large multinuclear giant cells surrounded by round and spindle cells. The cut surface of the tumour usually presents a deep red or maroon colour. While occasionally met with in tendon sheaths and bursæ, the myeloma occurs most frequently in the cancellous tissue at the ends of the long bones, its favourite site being the upper end of the tibia. Although formerly classified with the sarcomata, it is the exception for a myeloma to present malignant features, and it can usually be extirpated by local measures without fear of recurrence. The



FIG. 51.—Fibro-myoma of Uterus.
(Anatomical Museum, University of Edinburgh.)

method of removal varies with its situation, and is considered with diseases of bone. Sometimes the myeloma is met with in multiple form in the skeleton in association with an unusual form of protein in the urine (Bence Jones).

Myoma.—A myoma is a tumour composed of non-striped muscle fibres. Pure myomata are very rare. They are met with in organs possessed of non-striped muscle, such as the stomach, intestine, urinary bladder, and prostate; in the uterus, which is the most common situation for these tumours, as they contain a considerable admixture of fibrous tissue, they are known as *fibroids* or *fibro-myomata*. They present on section a fasciculated appearance, which may resemble that of

a section of balls of cotton (Fig. 51). They are encapsulated and vascular tumours, and they frequently attain a large size. They may be single or multiple. While they may occasion neither inconvenience nor suffering, they frequently give rise to profuse hæmorrhage from the uterus, and may cause serious symptoms by pressing injuriously on the ureters or the intestine, or by complicating pregnancy and parturition.

The **Rhabdomyoma** is an extremely rare form of tumour, met with in the kidney, uterus, and testicle. It contains striped muscle fibres, and is supposed to originate from a residue of muscular tissue which has become sequestered during development.

Glioma.—A glioma is a tumour composed of neuroglia. It is met with exclusively in the central nervous system, retina, and optic nerve. It is a slowly growing, soft, ill-defined tumour, which displaces the adjacent nerve centres and nerve tracts, and is liable to become the seat of hæmorrhage and thus to give rise to pressure symptoms resembling apoplexy. The glioma of the retina tends to grow into the vitreous humour and to perforate the globe. It is usually of the nature of a glio-sarcoma and is highly malignant.

Endotheliomata constitute a multiform group of new growths, which take origin from the endothelium of lymphatic vessels and spaces of blood-vessels, serous cavities, bursæ, and of the synovial membrane of joints and tendon sheaths. They show great variation in type, partly because of the number of different kinds of endothelium from which they are derived, and partly because the new connective tissue which is formed is liable to undergo transformation into hyaline, cartilaginous, or myxomatous tissue. They may be soft or hard, solid or cystic, diffuse or circumscribed; they grow very slowly, and are almost always innocent, although recurrence has been occasionally observed. The best-known example of endothelioma is the "mixed tumour" met with in the salivary glands and palate.

Angioma, lymphangioma, neuroma, and lymphoma are described with the disease of the individual tissues.

MALIGNANT CONNECTIVE-TISSUE TUMOURS—SARCOMATA

The term sarcoma is applied to any connective-tissue tumour which exhibits malignant characters. The essential structural feature is the predominance of the cellular elements over the intercellular substance or stroma, in which respect a sarcoma

resembles the connective tissue of the embryo. The typical sarcoma consists chiefly of immature or embryonic connective tissue. While these tumours may grow from any of the connective tissues of the body, they most frequently originate from fascia, intermuscular connective tissue, periosteum, bone-marrow, and skin. They form rounded or nodulated tumours which appear to be encapsulated, but the capsule merely consists of the condensed surrounding tissues, and usually contains sarcomatous elements. The consistence of the tumour depends on the nature and amount of the stroma, and on the presence of degenerative changes. The softer medullary forms are composed almost exclusively of cells; while the harder forms—such as the fibro-, chondro-, and osteo-sarcoma—are provided with an abundant stroma and are relatively poor in cells. Degenerative changes may produce areas of softening or liquefaction which result in the formation of cystic cavities in the interior of the tumour. The colour depends on the amount of blood in the tumour, and on the presence of degeneration.

The blood-vessels constitute a prominent feature in sarcomata, and although sometimes possessed of a definite wall, they are usually represented by mere chinks or spaces between the cells. This peculiarity accounts for the facility with which hæmorrhage takes place into the substance of the tumour, the persistence of the bleeding when the tumour is incised or ulcerates through the skin, and the readiness with which the sarcomatous cells may be carried off into the circulating blood and infect distant parts through the blood-stream. Sarcomata are devoid of lymphatics, and unless originating in lymphatic structures—for example, in the tonsil—they rarely infect the lymphatic glands. Minute portions of the tumour grow into the small veins, and, becoming detached, are transported by the blood-current to distant organs, where they are arrested in the capillaries and give rise to independent secondary growths. These are most frequently situated in the lungs, except when the primary growth lies within the territory of the portal circulation, in which case they occur in the liver. The secondary growths closely resemble the parent tumour. Sarcoma may invade an adjacent vein on such a scale that if the invading portion becomes detached it may constitute a dangerous embolus. This may be observed in sarcoma of the kidney, the growth taking place along the renal vein until it projects into the vena cava.

In their growth, sarcomata compress and destroy neighbouring parts, surround vessels and nerves, and may lead to destruction of the skin, either by invading it, or more commonly by causing sloughing from pressure. Inflammatory and suppurative changes may take place as a result of pyogenic infection. Once the skin is broken the tumour fungates through the opening. Sarcomata vary greatly in malignancy, especially as regards rapidity of growth and capacity for dissemination. Certain of them, such as the so-called "re-



FIG. 52.—Fungating Sarcoma of Arm.

current fibroid of Paget," grow comparatively slowly, and are only malignant in the sense that they tend to recur locally after removal; others—especially the more cellular tumours—grow with extreme rapidity, and are early disseminated throughout the body, resembling in these respects the most malignant forms of cancer. They are usually solitary in the first instance, although it is stated that primary multiple growths are occasionally met with in the skin and in the bones.

Many varieties of sarcoma are recognised, according to the structural peculiarities of the growth. Thus, according to the

size and character of the cells, we have the *small round-celled* and the *large round-celled* sarcomata, the *small* and *large spindle-celled* sarcomata, the *giant-celled* and the *mixed-celled* sarcomata. The *lympho-sarcoma* presents a structure similar to that of lymph-follicular tissue, and the *alveolar sarcoma*, an arrangement of cells in alveoli resembling that seen in cancers. When there is a considerable amount of intercellular fibrous tissue, the tumour is called a *fibro-sarcoma*.

The term *lymphangio-sarcoma* is applied when the cells of the tumour are derived from the endothelium of lymphatic spaces and vessels. The *angio-sarcomata* are those in which blood-vessels form a prominent element in the structure of the tumour. They are sometimes derived from innocent angiomata, and they may be so vascular as to pulsate and on auscultation yield a blowing murmur like an aneurysm. The *glio-sarcoma*, *myxo-sarcoma*, *chondro-sarcoma*, and *myo-sarcoma*, are mixed forms which usually develop in already existing innocent tumours. The *osteo-sarcoma* is characterised by the formation in the tumour of true bone, the medullary spaces being occupied by sarcomatous cells in place of marrow. The *osteoid sarcoma* is characterised by the formation of a tissue resembling bone but deficient in lime salts, and the *petrifying sarcoma* by the formation of calcified areas in the stroma. These varieties, although met with chiefly in the skeleton, may occur in the soft tissues such as muscle, and in such organs as the mamma. The pigmented varieties include the *chloroma*, which is of a light-green colour, and the *melanotic sarcoma*, which is brown or black. The *psammoma* is a sarcoma containing a material resembling sand, and it is chiefly met with in the membranes of the brain.

Diagnosis of Sarcoma.—Sarcomata are to be differentiated from inflammatory swellings such as result from tubercle and syphilis, from innocent tumours, and from cancers. The points on which the diagnosis is founded are discussed with the different tissues and organs.

Treatment.—The removal of the tumour by operation is the traditional method of treatment; in order to be successful it must be undertaken before dissemination has taken place, and a considerable area of healthy tissue beyond the apparent margin of the growth must be removed. In tumours which approach the surface of the body, the overlying skin should also be sacrificed.

When the conditions are such as to render complete eradication of the disease by operation unlikely, it has been recom-

mended to perform a subcapsular enucleation of the tumour, and to follow this by the persistent use of the X-rays. The capsule of the tumour is incised, and the tumour tissue rapidly scooped out with the fingers. The capsule, after being wiped out with dry gauze, is painted with the following solution—pyoktanin five parts, phenol one part, alcohol twenty parts, water to make a hundred parts. The cavity must usually be packed with sterile gauze to arrest the hæmorrhage. The X-rays are then applied daily for months, and, even after apparent cure, exposures should be made once every two to eight weeks for several years. As a general rule the anode should be placed about 30 cms. from the skin, and the time of exposure should average from twenty to fifty minutes. The application is divided between different areas, so that the rays may penetrate the diseased part from every possible direction. We have had no experience of this method of treatment.

In cases which do not lend themselves to any form of operative interference—*inoperable sarcoma*—the X-rays alone may be employed, or recourse may be had to the injection of the mixed toxins of the streptococcus of erysipelas and the bacillus prodigiosus (Coley). This method of treatment was suggested by the fact that an intercurrent attack of erysipelas had occasionally been observed to result in the disappearance of a sarcoma. The material for injection, known as Coley's fluid, is prepared as follows: The two organisms are grown separately; the culture of the bacillus prodigiosus is reduced to a dry powder, and added in definite proportion to the streptococcus broth so that the strength and dosage may be estimated with a fair approach to accuracy. It is important to begin with a small dose—a quarter of a minim, diluted with a little boiled water. If the tumour is highly vascular, it is better to make the first injection at some distance from it, until the susceptibility of the patient has been ascertained. After a few doses it is safe in most cases to inject into the tumour itself. The dose is increased by a quarter of a minim when given into the tumour, by half a minim when injected remote from it, until the desired reaction ensues; the best results being obtained by doses sufficiently large to produce a severe reaction, with a temperature of from 102° to 105° F. The frequency of the injections depends upon the strength of the patient, some being able to bear daily injections, others can stand only three or four injections a week.

In successful cases the effect is usually noticeable within

two or three days, the tumour becoming smaller, more movable, and less vascular. Coley maintains that when the tumour disappears from the use of the toxins, the permanence of the cure appears to be greater than after any other form of treatment. Unfortunately, the rigors, the headache, the fever, the sweats, and the general exhaustion which follow the injections are not infrequently unbearable, and further treatment is declined by the patient.

Coley also employs the toxins after operations for sarcoma as a prophylactic against recurrence; when thus used, the large doses required in inoperable cases are unnecessary. Injections sufficient to cause a reaction of, say 99° to 100° F., repeated three or four times a week, are sufficient, and the patient need not be confined to bed. Coley's plan is to give two or three periods of treatment, each from four to six weeks in duration. We have seen no benefit from Coley's fluid.

EPITHELIAL TUMOURS

An excessive and erratic growth of epithelium is the essential and distinguishing feature of the tumours in this class. The innocent forms are the papilloma and the adenoma; the malignant, the carcinomata or cancers.

Papilloma.—Papillomata are tumours which project from a cutaneous or mucous surface, and consist of a central axis of vascular fibrous tissue with a covering of epithelium which resembles that of the surface from which the tumour grows. In the papillomata of the skin—commonly known as *warts*—the covering consists of epidermis; in those growing from mucous surfaces it consists of the epithelium covering the mucous membrane. When the surface epithelium projects as filiform processes, the tumour is called a *villous papilloma*, the best-known example of which is met with in the urinary bladder. Papillomatous growths are also met with in the larynx, in the ducts of the breast, and in the interior of certain cystic tumours of the breast and of the ovary. Although papillomata are primarily innocent, they may ultimately become the starting-point of cancer. The clinical features and treatment of the various forms of papilloma are considered with the individual tissues and organs.

Adenoma.—An adenoma is a tumour constructed on the type of, and growing in connection with, a secreting gland. In the substance of such glands as the mamma, parotid, thyroid,

and prostate, adenomata are met with as encapsulated tumours. When they originate from the glands of the skin or of a mucous membrane, they tend to project from the surface, and form pedunculated tumours or polypi.

Adenomata may be single or multiple, and they vary in size from a pea to an adult human head. The tumour is seldom composed entirely of gland tissue; it usually contains a considerable proportion of fibrous tissue, and is then called a *fibro-adenoma*. When it contains myxomatous tissue it is called a *myxo-adenoma*, and when the gland spaces of the tumour become distended with accumulated secretion, a *cystic adenoma*, the best examples of which are met with in the mamma and ovary. A characteristic feature of the cystic variety is the tendency the tumour tissue exhibits to project into the interior of the cysts, constituting what are known as *intracystic growths*. They are essentially innocent, and, when removed by operation, show no tendency to recur. At the same time, transition forms between adenoma and carcinoma are not uncommonly met with, especially in the breast and intestine, and these should be treated on the same lines as cancer.

CARCINOMATA OR CANCERS

A cancer is a malignant tumour which originates in epithelium. The cells which form the essential constituent of a cancer are derived by proliferation from already existing epithelium, and they invade the sub-epithelial connective tissue in the form of simple or branching columns. These columns are enclosed in spaces—termed *alveoli*—which are probably dilated lymphatic spaces, and which communicate freely with the lymphatic vessels. The cells composing the columns and filling the alveoli vary with the character of the epithelium in which the cancer originates. The malignancy of cancer depends on this capacity which the epithelium has of invading the tissues in its neighbourhood, and on the capacity of the cells, when transported elsewhere by the lymph or blood-stream, of giving rise to secondary growths.

Cancer may arise on any surface covered by epithelium or in any of the secreting glands of the body, but it is much more common in some situations than in others. It is very frequently met with, for example, in the skin, in certain portions of the alimentary canal, in the breast, the uterus, and the external genitals; less frequently in the gall-bladder, larynx, thyroid, prostate, kidney, and urinary bladder.

Tissues appear to be most liable to cancer when, having

attained maturity, they enter upon the phase of decadence or involution, and this phase is reached by different tissues at different periods in the life of the organism. It is not so much, therefore, the age of the person in whom it occurs, as the age of the tissue in which it arises, that determines the maximum incidence of cancer. Cancers of the stomach appear and attain a maximum frequency earlier than cancers of the skin; cancers of the uterus and mamma are more frequent towards the decline of reproductive activity than in the later years of life. Rectal cancer is not infrequently met with during the second and third decades.

A cancer may appear as a papillary growth from a mucous or a skin surface, as an imperfectly circumscribed nodule in the substance of an organ, or as a diffuse thickening of a tubular organ such as the intestine or stomach. The absence of definition in cancerous tumours explains the difficulty in completely removing them by surgical measures, and has led to the practice of complete extirpation of cancerous organs wherever this is possible. The boundaries of the affected organ are, moreover, frequently transgressed by the disease, and the epithelial infiltration implicates the surrounding parts. In cancer of the breast, for example, the disease often extends to the adjacent skin, fat, and muscle; in cancer of the lip or tongue, to the lower jaw; in cancer of the uterus or intestine, to the investing peritoneum. In addition to its tendency to infiltrate adjacent tissues and organs, cancer is also liable to give rise to secondary growths. These are most often met with in the nearest lymphatic glands: those in the neck, for example, becoming infected from cancer of the lip, tongue, or throat; those in the axilla, from cancer in the breast; those along the curvatures of the stomach, from cancer of the pylorus; and those in the groin, from cancer of the external genitals. In lymphatic vessels the cancer cells may merely accumulate so as to fill the lumen and form indurated cords, or they may proliferate and give rise to secondary nodules along the course of the vessels. When the lymphatic network in the skin is diffusely infected, the appearance is either that of a multitude of secondary nodules or of a diffuse thickening, so that the skin comes to resemble coarse leather. On the wall of the chest this condition is known as *cancer en cuirasse*. Although the cancer cells very constantly attack the walls of the adjacent veins and spread into their interior at an early period, secondary growths due to dissemination by the bloodstream rarely show themselves clinically until late in the

course of the disease. It is probable that many of the cancer cells which are carried away in the blood or lymph stream undergo necrosis and fail to give rise to secondary growths. Secondary growths present a faithful reproduction of the structure of the primary tumour. Apart from the lymphatic glands, the chief seats of secondary growths are the liver, lungs, serous membranes, and bone marrow.



FIG. 53.—Carcinoma of Breast with Cancerous Ulcer.

The tumour tissue may undergo necrosis, and when the overlying skin or mucous membrane gives way an ulcer is formed. The margins of a *cancerous ulcer* are made up of tumour tissue which has not broken down. Usually they are irregular, nodularly thickened or indurated; sometimes they are raised and crater-like. The floor of the ulcer is smooth and glazed, or occupied by necrosed tissue, and the discharge is watery and blood-stained, and as a result of putrefactive changes may

become offensive. Hæmorrhage is rarely a prominent feature, but the discharge of blood may constitute a symptom of considerable diagnostic importance in cancer of internal organs such as the rectum, the bladder, or the uterus.

The Contagiousness of Cancer.—A limited number of cases are on record in which a cancer appears to have been transferred by contact, as from the lower to the upper lip, from one labium majus to the other, from the tongue to the cheek, and from one vocal cord to the other; these being all examples of cancer involving mucous surfaces which are constantly or frequently in contact. The transference of cancer from one human being to another, whether by accident, as in the case of a surgeon wounding his finger while operating for cancer, or by the deliberate introduction of a portion of cancerous tumour into the tissues, has never been known to be followed by the development of cancer. It is by no means infrequent, however, that when recurrence takes place after an operation for the removal of cancer, the recurrent growths make their appearance in relation to the main scar of the wound or of the scars of stitches in its neighbourhood. In the lower animals the grafting of cancer only succeeds in animals of the same species; for example, a cancer taken from a mouse will not grow in the tissues of a rat, but only in a mouse of the same variety as that from which the graft was taken.

While cancer cannot be regarded as either contagious or infectious so far as the community is concerned, it is important to bear in mind the possibility of infection of a wound with cancer when operating for the disease. Cancers should not be cut into unless for purposes of diagnosis, and the wound made for exploration should be tightly closed by stitches before the curative operation is proceeded with; the instruments used for the exploration must not be used again until they have been boiled. The greatest care should be taken that cancers which have softened or broken down are not opened into during the operation.

Investigations regarding the cause of cancer have been prosecuted with great energy during recent years in all parts of the world, but as yet without positive result. It is recognised that there are a number of conditions which favour the development of cancer, such as prolonged irritation, and a considerable number of cases have been recorded in which cancer of the skin of the hands has followed prolonged and repeated exposure to the Röntgen rays.

The Alleged Increase of Cancer.—Regarding the alleged

increase of cancer, it may be pointed out that the question how far available statistics represent a real increase cannot be satisfactorily solved, because it is impossible to ascertain how much of the apparent increase is due to more accurate diagnosis and improved registration. It is very probable also that some increase has taken place in consequence of the increased average length of life; a larger proportion of persons now reach the age at which cancer is most frequent.

The prognosis largely depends on the particular variety of cancer and on its situation. Certain varieties—such as the atrophic cancer of the breast which occurs in old people, and some forms of cancer in the rectum—are so indolent in their progress that they can scarcely be said to shorten life; while others—such as the softer varieties of mammary cancer occurring in young women—are among the most malignant of tumours. The mode in which cancer causes death depends to a large extent upon its situation. In the gullet or stomach, for example, it usually causes death by starvation; in the larynx or thyroid, by suffocation; in the intestine, by obstruction of the bowels; in the uterus, prostate, and bladder, by hæmorrhage, or by implication of the ureters and kidneys. Independently of their situation, however, cancers frequently cause death by giving rise to a progressive impairment of health known as the *cancerous cachexia*, a condition which is due to the continued absorption of poisonous products from the tumour. The patient loses appetite, becomes emaciated, pale, and feverish, and gradually loses strength until he dies.

Treatment.—Removal by surgical means affords the best prospect of cure. “If carcinomatous disease is to be rooted out, its mode of spread by means of the lymphatic vessels must be borne in mind, and as this occurs at an early stage, and is not evident on examination, a very wide area must be included in the operation. The organ from which the original growth springs should, if practicable, be altogether removed, because its lymphatic vessels generally communicate freely with each other, and secondary deposits have probably already taken place in various parts of it. In addition, the nearest chain of lymphatic glands must also be removed, even though they may not be noticeably enlarged, and in some cases—in cancer of the breast, for example—the intervening lymphatic vessels should be removed at the same time” (Watson-Cheyne).

The treatment of cancer by other than operative methods has received a great deal of attention within recent years, and many agents have been put to the test but without any

positive results. Most benefit has resulted from the use of the X-rays and of radium.

Influence of the X-rays on Cancer.—It has been demonstrated that cancer cells are more sensitive to the Röntgen rays than the normal cells of the body, and are more easily killed. The effect of the rays varies a good deal with the nature and seat of the tumour. In rodent cancers of the skin, for example, the X-ray treatment is very successful, and is to be preferred to operation because it yields a better cosmetic result. While small epitheliomata of the skin may be cured by means of the rays, they are not so amenable as rodent cancers.

Cancers of mucous membranes, such as those of the nose and mouth, are more resistant to X-ray treatment than those of the skin, because of the difficulty of access, their more rapid growth, and the frequent infection of the lymphatic glands. In cancers situated in the deeper tissues, such as cancer of the breast, while the growth of the tumour may be retarded and secondary nodules made to disappear, it is doubtful if a permanent cure ever results from their use. In inoperable cancers complicated with an open ulcer, X-rays are of service in improving the condition of the ulcer, lessening pain, improving the general health, and prolonging life. In malignant tumours of internal organs, X-rays have little or no influence.

In employing X-rays there is a danger of the applications being of too long duration, or of giving them too often. This, however, can hardly be avoided, because the treatment must be pushed to its extreme limit to afford any prospect of obtaining the desired result. The formation of an X-ray ulcer is a very undesirable complication, because, apart from the risk of secondary infection, it usually necessitates interruption of the treatment.

X-ray treatment is not to be looked upon as a rival but as a powerful supplement to the operative treatment of cancer. If the disease lends itself to radical removal by operation, this should always be undertaken, and the X-rays may be applied to the open wound at the completion of the operation; or the wound is allowed to heal and the rays applied afterwards through the skin.

Radium exerts a selective influence upon cancer cells similar to that exerted by X-rays, that is to say, the tumour cells offer less resistance to their toxic influence. In cancers of the skin and subcutaneous tissue, the metal tube containing the radium salt is secured in position by strips of plaster; experience is

required in judging the exposure which is necessary to obtain the maximum influence on the cancer cells with least damage to the healthy tissues. In deeply seated cancers, the tube, which is preferably made of silver or gold, should be implanted in the centre of the tumour, and for this purpose a track is made by a trocar and cannula or a bistoury; by means of a thread attached to the tube its position can be changed from day to day or every two or three days in order to subject successive portions of the tumour to the action of the radium. In the case of small, deeply seated tumours, an open dissection may be necessary in order to plant the tube accurately in its interior. It has been found that the influence of the implanted radium is augmented by the application of another tube of radium to the skin over the tumour, thus obtaining a cross-fire action of the rays. In the cavities of the body, such as the mouth, vagina, or rectum, the method of application must be adapted to the circumstances of the individual case.

The experience already gained in the use of radium shows that while it cannot be regarded as a substitute for a radical operation when this is possible, it is of value after operation with the object of preventing recurrence, and it is sometimes of great value in inoperable and otherwise hopeless cases.

VARIETIES OF CANCER

The varieties of cancer are distinguished according to the character and arrangement of the epithelial cells.

The *squamous epithelial cancer* or *epithelioma* originates from a surface covered by squamous epithelium, such as the skin, or the mucous membrane of the mouth, gullet, larynx, bladder, and external genitals. The epithelial columns which constitute the cancer retain the characters of squamous epithelium, and, being confined within the lymphatic spaces of the sub-epithelial connective tissue, become compressed and undergo a horny change. This results in the formation of concentrically laminated masses known as "cell nests" or "epithelial pearls."

The clinical features are usually those of a slowly growing indurated tumour, which nearly always ulcerates; there is a characteristic induration of the edges and floor of the ulcer, and its surface is often covered with warty or cauliflower-like outgrowths. The infection of the lymphatic glands is remarkably early and constant, and constitutes the most dangerous feature of the disease; the secondary growths in the glands

exhibit the characteristic induration, and may themselves break down into ulcers.

Epithelioma frequently originates in long-standing ulcers or sinuses, and in scars, and probably results from the displacement and sequestration of epithelial cells during the process of cicatrization.

The *columnar epithelial cancer* or *columnar epithelioma* origin-

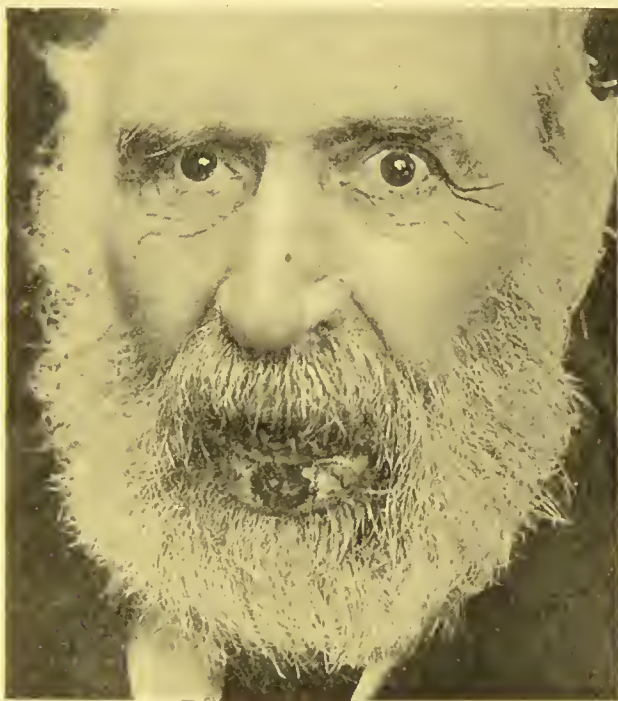


FIG. 54.—Epithelioma of Lip.

ates in mucous membranes covered with columnar epithelium, and is chiefly met with in the stomach and intestine. It is sometimes described as a *malignant adenoma*, because of its close structural resemblance to the innocent adenoma. Its malignancy is shown by the proliferating epithelium invading the other coats of the stomach or intestine, and by the fact that it gives rise to secondary growths.

Glandular carcinoma originates in glandular organs, such as the breast, and in the glands of mucous membranes and skin. The epithelial cells are not arranged on any definite plan, but are closely packed in irregularly shaped alveoli. If the alveoli

are large and the intervening stroma is scanty and delicate, the tumour is soft and brain-like, and is described as a *medullary* or *encephaloid cancer*. If the alveoli are small and the intervening stroma is abundant and composed of dense fibrous tissue, the tumour is hard, and is known as a *scirrhus cancer*—a form which is most frequently met with in the breast. If the cells undergo degeneration and absorption and the stroma contracts, the tumour becomes still harder, and tends to shrink and to draw in the surrounding parts, in the breast leading to retraction of the nipple and overlying skin, and in the stomach and intestine to narrowing of the lumen. When the cells of the tumour undergo colloid degeneration, a *colloid cancer* is produced. Melanin pigment is formed in relation to the cells and stroma of certain epithelial tumours, giving rise to *melanotic cancer*. *Cystic carcinomata* are those in which cyst-like spaces are formed in the tumour by the accumulation of the secretion of the epithelial cells, or as a result of their degeneration. They are met with chiefly in the breast and ovary, and resemble very closely the cystic adenomata, only they tend to infect their surroundings and give rise to secondary growths.

Rodent cancer originates in the glands of the skin, and presents a special tendency to break down and ulcerate on the surface. It very rarely infects the adjacent lymphatic glands.

DERMOIDS

A dermoid is defined as a tumour containing skin or mucous membrane, and occurring in a situation where these tissues are not met under normal conditions.

Skin dermoids, or *Derma-cysts* as they have been called by Askanazy, arise from portions of epiblast sequestered or detached in the course of development. When coalescence is taking place between two cutaneous surfaces, a portion of epiblast becomes sequestered, and remains embedded until at some future period it becomes the starting-point of a dermoid. Such a dermoid usually presents the form of a globular cyst, the wall of which consists of skin, and the contents of turbid fluid containing desquamated epithelium, fat droplets, cholesterin crystals, and detached hairs. Delicate hairs may also be found projecting from the epithelial lining of the cyst. Such dermoids occur on the trunk in situations where the lateral halves of the body coalesce during development, but they are more commonly met with on the face and neck in the situation

of the various clefts and fissures of the embryo. Faulty coalescence of the cutaneous covering of the back occurs most frequently over the lower sacral vertebræ, giving rise to small congenital recesses, known as post-anal dimples and coccygeal sinuses. These recesses are lined with skin, which is furnished with hairs, sebaceous and sweat glands. If the external orifice becomes occluded, there results a dermoid cyst.

Tubulo-dermoids arise from embryonic ducts and passages that are normally obliterated at birth; they are illustrated by those related to the thyro-glossal duct (lingual dermoids), the post-anal gut (rectal and post-rectal dermoids), and the branchial clefts (branchial dermoids). Tubulo-dermoids present the same structure as skin dermoids, save that in so far as they arise from a tube lined by mucous membrane this takes the place of skin in the wall of the cyst, and the contents consist of the pent-up secretion of mucous glands.

Clinical Features.—Although dermoids are of congenital origin, they are rarely evident at birth, and may not give rise to visible tumours until puberty, when the skin and its appendages become more active, or not till adult life. Superficial dermoids, such as those met with at the outer angle of the orbit, form rounded, definitely limited tumours, over which the skin is freely movable. They are usually adherent to the deeper parts, and when situated over the skull they may be lodged in a depression or actual gap in the bone. Sometimes the cyst becomes infected and suppurates, and finally ruptures on the surface. This may lead to a natural cure, or a persistent sinus may remain. Dermoids more deeply placed, such as those within the thorax, or those situated between the rectum and sacrum, give rise to considerable difficulty in diagnosis, and their nature is seldom recognised until the escape of the contents—particularly hairs—supplies the clue. The literature of dermoid cysts is full of accounts of puzzling tumours met with in all sorts of situations.

The treatment is to remove the cyst. When it is impossible to remove the whole of the lining membrane by dissection, the portion that is left should be destroyed with the cautery.

Ovarian Dermoids.—Dermoids are not uncommon in the ovary (Fig. 55). They usually take the form of unilocular or multilocular cysts, the wall of which contains skin, mucous membrane, hair follicles, sebaceous, sweat, and mucous glands, nails, teeth, nipples, and mammary glands. The cavity of the cyst usually contains a pultaceous mixture of shed epithelium,

fluid fat, and hair. If the cyst ruptures, the epithelial elements are diffused over the peritoneum, and may give rise to secondary dermoids.

The histogenesis of ovarian dermoids has given rise to considerable difference of opinion. By many they are regarded as taking origin from the epiblast, and as containing only epiblastic structures; recent observations, and especially those of Askanazy, would appear to show that they may contain tissues derived from all three layers of the embryo, and that no hard



FIG. 55—Dermoid Cyst of Ovary showing Teeth in its Interior.

and fast line can be drawn between an ovarian dermoid and a teratoma.

The ovarian dermoid appears clinically as an abdominal or pelvic tumour provided with a pedicle; if the pedicle becomes twisted, the tumour undergoes strangulation, an event which is attended with urgent symptoms, not unlike those of strangulated hernia.

The treatment consists in removing the tumour by laparotomy.

Teratoma.—A teratoma is distinguished from a dermoid not only by its usually containing tissues or structures derived from all the germinal layers of the embryo, but also by the embryonic character of the tissues, by the greater rapidity of their growth, and by their tendency to give rise to metastases. Teratomata are believed to result from partial dichotomy or cleavage of the trunk axis of the embryo, and are found exclusively in connection with the skull and vertebral column. They include such monstrosities as conjoined twins or parasitic foetus. They are more commonly met with as irregularly shaped tumours, usually growing from the posterior surface of the sacrum. On dissection, these are found to contain a curious mixture of tissues—bones, skin, and portions of viscera, such as the intestine or liver. The question of the removal of such tumours requires to be considered in relation to the conditions present in each individual case.

CYSTS¹

Cysts are usually rounded sacs, the wall being composed of fibrous tissue lined by epithelium or endothelium; the contents are fluid or semi-solid, and vary in character according to the organ or tissue in which the cyst has originated.

Retention and Exudation Cysts.—*Retention cysts* develop when the duct of a secreting gland is partly obstructed; the secretion accumulates, and the gland and its duct become distended into a cyst. They are frequently met with in the mamma and pancreas, and in the salivary mucous and sebaceous glands. Sebaceous cysts or wens are described with diseases of the skin, and other retention cysts with their respective regions. *Exudation cysts* arise from the distension of cavities which are not provided with excretory ducts, such as those in the thyroid.

Implantation cysts are caused by the accidental implantation of portions of the epidermis into the underlying connective tissue, as may occur in accidental wounds by needles, awls, forks, or thorns. The implanted epidermis proliferates and forms a small cyst. They are met with chiefly on the palmar aspect of the fingers, and vary in size from a split pea to a cherry. The treatment consists in removing them by dissection.

Parasitic cysts are produced by the growth within the

¹ Cysts which form in relation to new growths have been considered with tumours.

tissues of cyst-forming parasites, the best known being the *tænia echinococcus*, which gives rise to the *hydatid cyst*.

The parent worm, the *tænia echinococcus*, inhabits the intestine of the dog, and its ova are passed with the fæces. Having gained entrance to the stomach of the intermediate host, the embryos are liberated; they bore through the wall of the intestine and reach venous and lymphatic channels, by which they are distributed throughout the body. When the embryo reaches its destination it loses its hooks, enlarges, becomes converted into a cyst, around which granulation tissue forms. The liver is by far the most common site of hydatid cysts in the human subject.

The wall of the fully formed cyst is composed of an internal granular layer or endocyst; a laminated, elastic outer layer or ectocyst; and an adventitious capsule of fibrous tissue. From the endocyst are formed brood capsules and scolices, the latter representing the heads of the young echinococci, and exhibiting a series of suckers and a row of hooklets. The fluid within the cyst is colourless, usually neutral in reaction, devoid of albumen, and contains a trace of sodium chloride, and other elements which vary with the organ in which the cyst is embedded. The inner layer of the parent cyst frequently gives origin to daughter cysts which may occupy the interior of the parent cyst or lie outside it, the latter being the usual arrangement in the marrow of bone.

Charles MacLaurin believes that daughter cysts only form when the mother cyst is disturbed or hindered in its growth; daughter cysts, for example, are almost never found in hydatid cysts of the brain, because they are protected from injury and from infection, and death occurs before serious pressure interferes with the growth of the cyst. They are also rare in the lung, because the mother cyst is well protected, and when it does tend to become large it ruptures into a bronchus. Daughter cysts are common in hydatids of the liver, the muscles, and the bones.

With regard to the further life-history of hydatids, the living elements of the cysts may die and degenerate, or the cyst may increase in size until it ruptures. As a result of pyogenic infection the cyst may be converted into an abscess.

The *clinical features* of hydatids vary so much with their situation and size, that they are best discussed with the individual organs. In general it may be said that there is a slow formation of a globular, elastic, fluctuating, painless swelling. Fluctuation is detected when the cyst approaches

the surface, and it is then also that percussion may elicit the "hydatid thrill" or fremitus. This thrill is not often obtainable, and in any case is not pathognomonic of hydatids, as it may be elicited in ascites and in tense abdominal or pelvic cysts. Pressure of the cyst upon adjacent structures, and the occurrence of suppuration, are attended with characteristic clinical features.

The *diagnosis* of hydatids will be considered with the individual organs. The disease is more common in certain parts of Australia and in Shetland and Iceland than in countries where the association of dogs in the domestic life of the inhabitants is less intimate.

The *treatment* is to excise the cyst completely, or to inject into it a 1 per cent. solution of formalin. In operating upon hydatids the utmost care must be taken to avoid leakage of the contents of the cyst, as these may readily disseminate the infection.

Blood cysts result from the encapsulation of extravasated blood in the tissues, from hæmorrhage taking place into a pre-formed cyst, or from the saccular pouching of a varicose vein.

Lymph cysts may result from contusions in which the skin is forcibly displaced from the subjacent tissues, and lymphatic vessels are thereby torn across. The cyst is usually situated between the skin and fascia, and contains clear or blood-stained serum. At first it is lax and fluctuates readily, later it becomes larger and more tense. In contrast with hæmorrhagic effusions, there is little tendency to absorption. The treatment consists in drawing off the contents through a hollow needle and applying firm pressure. These cysts were formerly confused with blood cysts; their true nature was first recognised by Gegenbauer.

Apart from injury, lymph cysts are met with as the result of the distension of lymphatic spaces and vessels (*lymphangiectasis*); and in lymphangiomata, of which the best-known example is the cystic hygroma or hydrocele of the neck.

GANGLION

This term is applied to a cyst filled with a clear jelly or colloid material, met with in the vicinity of a joint or tendon sheath.

The *carpal ganglion*—popularly known as a sprained sinew—is met with as a smooth, rounded, or oval swelling on the dorsal aspect of the carpus, usually towards its radial side

(Fig. 56). It is situated over one of the intercarpal or other joints in this region, and may appear to be connected with one or other of the extensor tendons. The skin and fascia are movable over the cyst. The cyst varies in size from a pea to a pigeon's egg, and usually attains its maximum size within a few months. It becomes tense and more prominent when the hand is flexed towards the palm. Its appearance is usually ascribed to some strain of the wrist—for example, in girls learning gymnastics, or in women after a heavy washing. It may cause no symptoms beyond the deformity, or it may interfere with the use of the hand, especially in grasping movements and when the hand is dorsiflexed. In females it may give rise to pain which shoots up the arm. Ganglia are also met with on the dorsum of the metacarpus and on the palmar aspect of the wrist.



FIG. 56.—Carpal Ganglion in a woman aged 25.

The tarsal ganglion is situated on the dorsum of the foot over one or other of the intertarsal joints. It is usually smaller, flatter, and more tense than that met with over the wrist, so that it is sometimes mistaken for a bony tumour. It rarely causes any symptoms, unless so situated as to be pressed upon by the boot.

Ganglia in the region of the knee are usually situated over the interval between the femur and tibia, most often on the outer aspect of the joint in front of the tendon of the biceps (Fig. 57). The swelling, which may attain the size of half a walnut, is tense and hard when the knee is extended, and becomes softer and more prominent when it is flexed. They are met with chiefly in young adult males who follow laborious occupations or who indulge in athletics, and they may cause stiffness, discomfort, and impairment of the use of the limb.

Ganglionic cysts are met with in other situations than those described, but they are so rare as not to require separate mention.

Ganglia are to be diagnosed by their situation and physical characters; enlarged bursæ, synovial cysts, and new growths are the swellings most likely to be mistaken for them. The

diagnosis is sometimes only cleared up by withdrawing the clear, jelly-like contents.

Pathological Anatomy.—On dissection, the wall of the cyst is found to be composed of dense fibrous tissue closely adherent to or fused with the surrounding tissues, so that it cannot be shelled out. There is no endothelial lining, and the fibrous tissue of the wall is in immediate contact with the colloid material in the interior.

The microscopical appearances give the impression that the colloid material is derived by a process of degeneration from the surrounding fibrous connective tissue. In the region of the knee the ganglion is usually multilocular, and consists of a meshwork of fibrous tissue, the meshes of which are occupied by colloid material.

It is often stated that a ganglion originates from a hernial protrusion of the synovial membrane of a joint or tendon sheath into the surrounding tissues. We have not been able to demonstrate any communication between the cavity of the cyst and that of an adjacent tendon sheath or joint. It is possible, however, that the cyst may originate from a minute portion of synovial membrane being protruded and strangulated so that it be-

comes disconnected from that to which it originally belonged; it may then degenerate and give rise to colloid material, which accumulates and forms a cyst. Ledderhose and others regard ganglia as entirely new formations in the peri-articular tissues, resulting from colloid degeneration of the fibrous tissue of the capsular ligament, occurring at first in numerous small areas which later fuse to form a single cavity. Ganglia are probably,



FIG. 57.—Ganglion on outer aspect of Knee.

(From a photograph lent by Sir George T. Beatson.)

therefore, of the nature of degeneration cysts arising in the capsule of joints, and in tendon sheaths.

Treatment.—If a ganglion causes deformity or disability, it can be got rid of by an aseptic modification of the old-fashioned seton. The overlying skin and cyst wall are trans-fixed by a stout curved needle carrying a double thread of thick silkworm gut, the ends of which are cut short, and a dressing applied. A week later the threads are removed and the minute punctures sealed with collodion. The action of the threads is to excite an aseptic granulation of the cyst wall, which results in its obliteration. When this fails, recourse should be had to excision. Puncture with a tenotomy knife and scraping the interior, and the injection of irritants, are alternative, but less satisfactory, methods of treatment.

Ganglia in tendons are very rare, and when they do occur it is usually in young adults. The diagnosis rests on the observation that the small tumour is cystic, and that it completely follows the movements of the tendon. The cyst is at first multiple, but the partitions disappear, and all the spaces are thrown into one. The best treatment is to resect the affected segment of tendon.

The so-called “compound palmar ganglion” is a tuberculous disease of the tendon sheaths, and is described with diseases of tendon sheaths.

CHAPTER XII

INJURIES

CONTUSIONS—WOUNDS: *Varieties*—WOUNDS BY FIREARMS AND EXPLOSIVES: *Varieties*—BURNS AND SCALDS—INJURIES PRODUCED BY ELECTRICITY

CONTUSIONS

A CONTUSION or bruise is a laceration of the subcutaneous soft tissues, without solution of continuity of the skin. When the integument gives way at the same time, a *contused wound* results. Bruising occurs when force is applied to a part by means of a blunt object, whether as a direct blow, a crush, or a grazing form of violence. If the force acts at right angles to the part, it tends to produce localised lesions which extend deeply; while, if it acts obliquely, it gives rise to lesions which are more diffuse, but comparatively superficial. It is well to remember that those who suffer from scurvy, or hæmophilia (bleeders), and fat and anæmic females, are liable to be bruised by comparatively trivial injuries.

Clinical Features.—The less severe forms of contusion are associated with *ecchymosis*, numerous minute and discrete punctate hæmorrhages being scattered through the superficial layers of the skin, which is slightly œdematous. The effused blood is soon reabsorbed.

The more severe forms are attended with *extravasation*, the extravasated blood being widely diffused through the cellular tissue of the part, especially where this is loose and lax, as in the region of the orbit, the scrotum and perineum, and on the chest wall. A blue or bluish-black discoloration occurs in patches, varying in size and depth with the degree of force which produced the injury, and in shape with the instrument employed. It is most intense in regions where the skin is naturally thin and pigmented. In parts where the extravasated blood is only separated from the oxygen of the air by a thin

layer of epidermis or by a mucous membrane, it retains its bright arterial colour. These points are often well illustrated in cases of black eye, where the blood effused under the conjunctiva is bright red, while that in the eyelids is almost black. In severe contusions associated with great tension of the skin—for example, over the front of the tibia or around the ankle—blisters often form on the surface and constitute a possible avenue of septic infection. When deeply situated, the blood tends to spread along the lines of least resistance, partly under the influence of gravity, passing under fasciæ, between muscles, along the sheaths of vessels, or in connective-tissue spaces, so that it may only reach the surface after some time, and at a considerable distance from the seat of injury. This fact is sometimes of importance in diagnosis, as, for example, in certain fractures of the base of the skull, where discoloration appears under the conjunctiva or behind the mastoid process a few days after the accident.

Blood extravasated deeply in the tissues gives rise to a firm, resistant, doughy swelling, in which there may be elicited on deep palpation a peculiar sensation, not unlike the crepitus of fracture.

The majority of contusions tend to spontaneous cure, during the progress of which characteristic alterations in the colour of the effused blood take place as a result of changes in the blood pigment. In from twenty-four to forty-eight hours the margins of the blue area become of a violet hue, and as time goes on the discoloured area increases in size, and becomes successively green, yellow, and lemon-coloured at its margins, the central part being the last to change. The rate at which this play of colours proceeds is so variable, and depends on so many circumstances, that no time-limits can be laid down. During the disintegration of the effused blood the adjacent lymphatic glands may become enlarged, and on dissection may be found to be pigmented.

Sometimes the blood collects in a space—for example, under the aponeurosis of the occipito-frontalis, in the tunica vaginalis, or in a large connective-tissue space—and constitutes a *hæmatoma*. The encapsulation of such an effusion, by proliferation of the connective tissue around it, may give rise to a *hæmorrhagic cyst*.

It frequently happens that, from the tearing of lymphatic vessels, serous fluid is extravasated, and a *lymphatic* or *serous cyst* may form.

In all contusions accompanied by extravasation, there is

marked swelling of the area involved, as well as pain and tenderness. The temperature may rise to 101° F., or, in the large extravasations that occur in bleeders, even higher—a form of aseptic fever (Fig. 12). The degree of shock is variable, but sudden syncope frequently results from severe bruises of the testicle, abdomen, or head, and occasionally marked nervous depression follows these injuries.

Contusion of muscles or nerves may produce partial atrophy and paresis, as is often seen after injuries in the region of the shoulder.

In alcoholic or other debilitated patients, suppuration is liable to ensue in bruised parts, infection taking place from cocci circulating in the blood, or through the overlying skin.

Treatment.—If the patient is seen immediately after the accident, elevation of the part, and firm pressure applied by means of a thick pad of cotton wool and an elastic bandage, are useful in preventing effusion of blood. Ice-bags and evaporating lotions are to be used with caution, as they are liable to lower the vitality of the damaged tissues and lead to gangrene.

When extravasation has taken place before the patient is seen, massage is the most speedy and efficacious means of dispersing the effused blood. The part should be massaged several times a day, unless the presence of blebs or abrasions of the skin prevents this being done. When this is the case, the use of antiseptic dressings is called for to prevent infection and to promote healing, after which massage is employed.

When the tension caused by the extravasated blood threatens the vitality of the skin, incisions may be made, if asepsis can be assured. The blood from a hæmatoma may be withdrawn by an exploring needle, and the puncture sealed with collodion. Septic complications must be met on general principles.

WOUNDS

A wound is a solution in the continuity of the skin or mucous membrane and of the underlying tissues, caused by violence.

Three varieties of wounds are described: incised, punctured, and contused and lacerated.

Incised Wounds.—The best examples of incised wounds are those made by the surgeon in the course of an operation. Wounds accidentally inflicted by cutting instruments and suicidal cut-throat wounds are also of the incised variety. It.

should be borne in mind in connection with medico-legal inquiries, that wounds of soft parts that closely overlie a bone, such as the skull, the tibia, or the patella, although inflicted by a blunt instrument, may have all the appearances of incised wounds.

Clinical Features.—One of the most characteristic features of an incised wound is its tendency to gape. This is evident in long skin wounds, and especially when the cut runs across the part, or when it extends deeply enough to divide muscular fibres at right angles to their long axis. The gaping of a wound, further, is more marked when the underlying tissues are in a state of tension—as, for example, in inflamed parts. Incised wounds in the palm of the hand, the sole of the foot, or the scalp, however, have little tendency to gape, because of the close attachment of the skin to the underlying fascia.

Incised wounds, especially in inflamed tissues, tend to bleed profusely; and when a vessel is only partially divided and is therefore unable to contract, it continues to bleed longer than when completely cut across.

The *special risks* of incised wounds are: (1) division of large blood-vessels, leading to profuse hæmorrhage; (2) division of nerve-trunks, resulting in motor and sensory disturbances; and (3) division of tendons or muscles, interfering with motion. Septic infection is, of course, a risk common to all varieties of wounds.

Treatment.—If hæmorrhage is still going on, it must be arrested by pressure, torsion, or ligature, as the accumulation of blood in a wound interferes with union. If necessary, the wound should be purified, by washing with saline solution or peroxide of hydrogen, after which the edges are approximated by sutures. The raw surfaces must be brought into accurate apposition, care being taken that no inversion of the cutaneous surface takes place. In extensive and deep wounds, to ensure more complete closure and to prevent subsequent stretching of the scar, it is advisable to unite the different structures—muscles, fasciæ, and subcutaneous tissue—by separate series of *buried sutures* of catgut or other absorbable material. For the approximation of the skin edges, stitches of horse-hair, fishing-gut, or fine silk are the most appropriate. These *stitches of coaptation* may be interrupted (Fig. 60) or continuous (Figs. 58 and 59). In small superficial wounds on exposed parts, stitch marks may be avoided by approximating the edges with strips of gauze fixed in position by collodion, or by subcutaneous sutures of fine catgut. Where the skin is loose, as, for

example, in the neck, on the limbs, or in the scrotum, the use of Michel's suture clips is advantageous in so far as these bring the deep surfaces of the skin into accurate apposition, are introduced with comparatively little pain, and leave a very slight mark.

When there is any difficulty in bringing the edges of the wound into apposition, a few interrupted *relaxation stitches* may be introduced wide of the margins, to take the strain off the coaptation stitches (Fig. 60). Stout silk, fishing-gut, or silver wire may be employed for this purpose. When the tension is extreme, Lister's button suture (Fig. 58) may be employed. Relaxation stitches should be removed in four or five days, and stitches of coaptation in from ten to fourteen days. On the face and neck, wounds heal rapidly, and stitches may be removed in two or three days, thus diminishing the marks they leave.

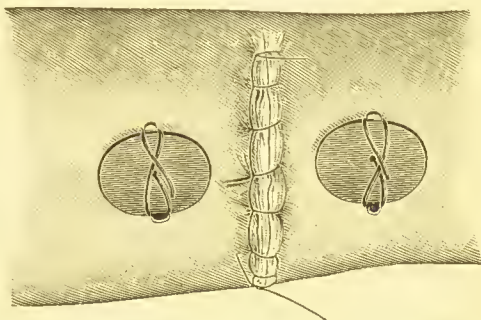


FIG. 58.—Continuous Suture, uniting Edges of Wound. Button Sutures of Relaxation.

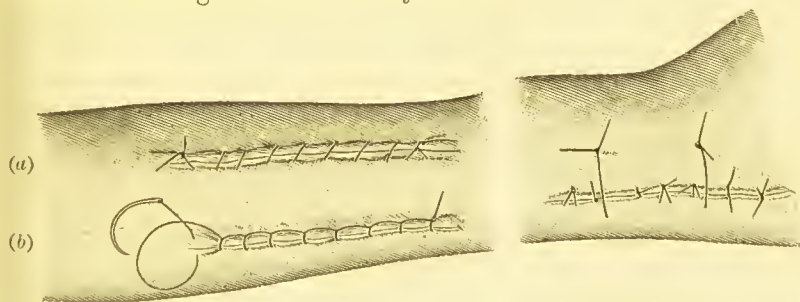


FIG. 59.—Continuous Sutures: (a) Glover's Stitch; (b) Blanket or Button-hole Stitch.

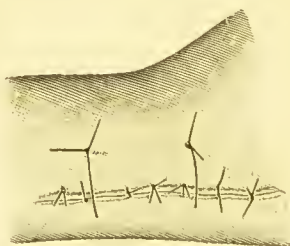


FIG. 60.—Interrupted Sutures. Two wide Sutures of Relaxation.

Drainage.—In wounds in which no cavity has been left, and in which there is no reason to suspect septic infection, drainage is unnecessary. When the deeper parts of an extensive wound cannot be brought into accurate apposition, however, and especially when there is any prospect of oozing of blood or serum—as in amputation stumps or after excision of the breast—drainage is indicated. It is a wise precaution also

to insert drainage-tubes into wounds in very fat patients when there is the slightest reason to suspect the presence of septic organisms. Glass or rubber tubes are the best drains; but where it is desirable to leave little mark, a few strands of horse-hair or of sterilised worsted, or a small roll of protective or rubber tissue, form a satisfactory substitute. Except when sepsis occurs, the drain is removed in from one to four days, and the opening closed with a Michel's clip or a suture.

The wound should be protected by means of suitable dressings, and the part kept at rest by bandages, splints, or other appropriate means.

Punctured Wounds.—Punctured wounds are produced by narrow, pointed instruments, and the sharper and smoother the instrument the more does the resulting injury resemble an incised wound; while from more rounded and rougher instruments the edges of the wound are always more or less contused or lacerated. The depth of punctured wounds greatly exceeds their width, and the damage to subcutaneous parts is usually greater than that to the skin. When the instrument transfixes a part, the edges of the wound of entrance may be inverted, and those of the exit wound everted. If the instrument is a rough one, these conditions may be reversed by its sudden withdrawal.

Punctured wounds neither gape nor bleed much. Even when a large vessel is implicated, the bleeding usually takes place into the tissues rather than externally.

The risks incident to this class of wounds are: (1) The extreme difficulty, especially when a dense fascia has been perforated, of rendering them aseptic, on account of the uncertainty as to their depth, and of the way in which the surface wound closes on the withdrawal of the instrument. (2) Different forms of aneurysm may result from the puncture of large vessels. (3) Perforation of a joint, or of a serous cavity, such as the abdomen, thorax, or skull, materially adds to the danger.

Treatment.—The first indication is to sterilise the whole extent of the wound, and to remove any foreign body that may have been left in it. That this may be done satisfactorily it is usually necessary to enlarge the wound, freely dividing injured fasciæ. Blood-clots are cleared out, bruised tissues pared away, and the whole wound-surface purified. Any blood-vessel that is punctured should be cut across and tied; and divided muscles, tendons, or nerves must be sutured. After hæmorrhage has been arrested, the wound is drained.

If there is any reason to doubt the asepticity of the wound, a Bier's bandage should be applied.

Contused and Lacerated Wounds.—These may be considered together, as they so occur in practice. They are produced by crushing, biting, or tearing forms of violence—such as result from machinery accidents, firearms, or the bites of animals. In addition to the irregular wound of the integument, there is always more or less bruising of the parts beneath and around, and the lesions are usually much wider in area than at first sight appears.

Wounds of this variety usually gape considerably, especially when there is much laceration of the skin. It is not uncommon to have considerable portions of skin, muscle, or tendon completely torn away.

Hæmorrhage is seldom a prominent feature, as the crushing or tearing of the vessel wall leads to the obliteration of the lumen.

The special risks of these wounds are: (1) Sloughing of the bruised tissues, especially when attempts to sterilise the wound have not been completely successful. (2) Reactionary hæmorrhage after the initial shock has passed off. (3) Secondary hæmorrhage as a result of septic processes ensuing in the wound. (4) Loss of muscle or tendon, interfering with motion. (5) Cicatricial contraction. (6) Gangrene, which may follow occlusion of main vessels, or virulent infective processes. (7) It is not uncommon to have particles of carbon embedded in the tissues after lacerated wounds, leaving unsightly, pigmented scars. This is often seen in coal-miners, and in those injured by firearms, and is to be prevented by carefully removing all gross dirt from the edges of the wound.

Treatment.—In severe wounds of this class implicating the extremities, the most important question that arises is whether or not the limb can be saved. In examining the limb, attention should first be directed to the state of the main blood-vessels, in order to determine if the vascular supply of the part beyond the lesion is sufficient to maintain its vitality. Amputation is usually called for if there is complete absence of pulsation in the distal arteries and if the part beyond is cold. If at the same time important nerve-trunks are lacerated, the probability of gangrene ensuing is increased. If, in addition, there is extensive destruction of large muscular masses or of important tendons, or comminution of the bones, amputation is usually imperative. Stripping of large areas of skin is not in itself a reason for removing a limb, as much can be done

by skin grafting, but when it is associated with other lesions it favours amputation. In considering these points, it must be borne in mind that the damage to the deeper tissues is always more extensive than appears at first sight, and that in many cases it is only possible to estimate the real extent of the injury by administering an anæsthetic and exploring the wound. In doubtful cases the possibility of rendering the parts aseptic will often decide the question for or against amputation. If thorough purification is accomplished, the success which attends conservative measures is often remarkable. It is permissible to run an amount of risk to save an upper extremity which would be quite unjustifiable in the case of a lower limb. The age and occupation of the patient must also be taken into account.

When it is decided to make the attempt to save the limb, the wound must be carefully and thoroughly purified. If necessary it may be enlarged, so that all bruised tissue in which gross dirt has become engrained may be clipped away with scissors. The raw surface should be thoroughly cleansed with sterilised salt solution or peroxide of hydrogen. All rough scrubbing with strong antiseptics is to be avoided, as being only calculated to depress the vitality of the tissues without increasing the probability of rendering the wound aseptic. The wound should be left unstitched, freely drained or packed with gauze, and immobilised by suitable splints, and passive hyperæmia should be produced by means of a Bier's bandage.

WOUNDS BY FIREARMS AND EXPLOSIVES

The present consideration of gun-shot wounds refers chiefly to such injuries as are met with in civil practice. The subject will be dealt with under the following heads:—Pistol-shot wounds, wounds by sporting-guns, wounds by rifle-bullets, and shell wounds.

Whatever the nature of the weapon, the wound is of the *contused and lacerated* variety. Its severity depends on the size, shape, and velocity of the missile, the range at which the weapon is discharged, and the part of the body struck.

Shock is a prominent feature in most cases of gun-shot wound, but its degree, as well as the time of its onset, varies with the extent and seat of the injury, and with the mental state of the patient when shot. At the moment of injury the patient experiences a sensation which is variously described as being like the lash of a whip, a blow with a stick, or an

electric shock. There is not much pain at first, but later it may become severe, and is usually associated with intense thirst, especially when much blood has been lost.

Recent experience has shown that even in active warfare the great majority of gun-shot wounds heal by first intention if treated on antiseptic principles from the first, by the intelligent application of the field dressing with which each soldier is provided.

Considerable difference of opinion exists as to the advisability of removing embedded bullets, some authorities holding that unless causing definite symptoms they should be left alone, while others advocate their extraction to obviate possible later complications and to relieve the mind of the patient. It is needless to say that, in localising bullets as a preliminary to operation, invaluable aid is obtained by the use of the Röntgen rays. By the aid of stereoscopic skiagraphy, or Mackenzie-Davidson's "cross-thread localiser," or by taking two or more skiagrams in different planes, the position of the bullet can be determined with great accuracy. This procedure has entirely superseded the employment of special probes and other instruments for this purpose.

Pistol-shot Wounds.—Wounds inflicted by pistols, revolvers, and small air-guns are of frequent occurrence in civil practice, the weapon being discharged usually by accident, but frequently with suicidal, and sometimes with homicidal intent.

With all calibres and at all ranges, except actual contact, the wound of entrance is smaller than the bullet. If the weapon is discharged within a foot of the body, the skin surrounding the wound is usually stained with smoke and burned, and the hair singed. At ranges varying from six inches to thirty feet, grains of powder may be found embedded in the skin or lying loose on the surface, the greater the range the wider being the area of spread. When black powder is used, the embedded grains usually leave a permanent bluish-black tattooing of the skin. When the weapon is placed in contact with the skin, the subcutaneous tissues are lacerated over an area of two or three inches around the opening made by the bullet, and smoke and powder staining and scorching are more marked than at longer ranges.

When the bullet perforates, the exit wound is usually larger and more extensively lacerated than the wound of entrance. Its margins are as a rule everted, and it shows no marks of flame, smoke, or powder.

Pistol wounds only produce dangerous effects when fired at

close range, and when the cavities of the skull, the thorax, or the abdomen are implicated. These injuries will be described with regional surgery.

Pistol-shot wounds of *joints* and *soft parts* are seldom of serious import apart from the risk of septic infection.

Treatment.—The treatment of recent wounds of the soft parts consists in purifying the bullet tracks with a view to preventing septic complications. An attempt may have to be made to remove the bullet, the exact position of which should, if possible, be determined by the use of the Röntgen rays. If the patient is not seen until the wound has healed, and if the bullet is deeply lodged and causes no inconvenience, it may be left alone. Probes should be avoided in searching for bullets in soft parts overlying joints or serous cavities; the wounds should be enlarged, if necessary, to admit the finger for purposes of exploration.

Wounds by Sporting-guns.—The weapons most commonly used in this country for sporting purposes are the 12- or 16-bore gun, and, less frequently, the smaller 20-bore. The cartridges are usually loaded with amberite or other smokeless powder, and carry a charge of from two to three hundred small pellets (No. 5 or No. 6 shot), weighing from 300 to 450 grains.

The charge of small shot leaves the muzzle of the gun as a cylinder, gradually becoming spherical as the pellets scatter, till, at about twenty feet from the muzzle, the dispersion is complete, each pellet taking its own course.

When the object struck is within one and a half to two feet of the muzzle of the gun, the charge makes a single, sharply cut wound, somewhat oval in outline, having much the appearance of a wound produced by a single bullet. The wound of exit is much larger and more ragged, and the tissues through which the charge has passed are torn and lacerated by the scattering of the pellets. If a bone is struck it is shattered, and the soft parts around it are destroyed by the deflection of the shot, which tear up the tissues through which they pass. Portions of bone may be driven out through the exit wound and cause great laceration of its edges.

Pellets striking the shafts of long bones may become flattened or distorted, and when cancellated bone is struck they remain embedded in it.

When the charge impinges over one of the large cavities of the body, the shot may scatter widely through the contained viscera, and there is often no exit wound. In the thorax, for example, if a rib is struck, the charge, and possibly frag-

ments of bone, will penetrate the pleura, and be dispersed throughout the lung; in the head, the skull may be shattered and the brain torn up; and in the abdomen, the hollow viscera may be perforated in many places and the solid organs lacerated.

On covered parts the clothing, by deflecting the shot, influences the size and shape of the wound; the entrance wound is increased in size and more ragged, and portions of the clothes may be driven into it.

By the discharge of small shot at a distance of from two to four feet from the muzzle, the central wound is slightly ragged; and beyond four feet, the pellets begin to disperse so that there are separate punctures round the central opening. As the distance increases these outlying punctures make a wider and wider pattern, till at ten feet they cover an area of about five inches. The central opening is at its largest about six or seven feet from the muzzle; beyond this it gradually gets smaller, till at ten or fifteen feet it is scarcely recognisable, and at twenty feet it has completely disappeared, each individual pellet making its own puncture.

When the shot have diverged so as to strike singly, they seldom do much harm, but fatal damage may be done to the brain or to the aorta, or the eye may be seriously injured by a single pellet. When a large number of pellets lodge close to one another, the skin is very apt to slough.

Small shot fired at longer ranges—up to about a hundred and fifty feet—usually go through the skin, but seldom pierce the fascia, and lie embedded in the subcutaneous tissue, from which they can readily be extracted.

The wad of the cartridge behaves very erratically: so long as it remains flat it goes off with the rest of the charge, and is often buried in the wound; but if it curls up or turns on its side it is usually deflected and flies clear of the shot. It may make a separate wound.

A charge of small shot is much more destructive to blood-vessels, tendons, and ligaments than a single bullet, which in many cases pushes such structures aside without actually dividing them. In the abdomen and chest, also, the damage done by a full charge of shot is much more extensive than that inflicted by a single ball, the deflection of the pellets leading to a greater number of perforations of the intestine and more widespread laceration of solid viscera.

When a charge of small shot fired at close range strikes the surface of the body obliquely, considerable portions of soft

tissues may be carried away, leaving a large ragged wound, with torn margins, in which stray pellets are often embedded.

Wounds by Rifle-bullets.—The vast majority of wounds inflicted by rifle-bullets are met with in the field during active warfare, and fall to be treated by military surgeons. They occasionally occur accidentally, however, during range practice, and may then come under the notice of the civil surgeon.

It is only necessary here to consider the effects of modern small-bore bullets—that is, anything less than 0.350 inch in diameter, as no others are now used by civilised armies.

The Lee-Enfield rifle, which is the present arm of the British army, fires a bullet 1.25 inch in length, 0.311 inch in diameter, and weighing about 215 grains. It is composed of a core of lead hardened with antimony, encased in an envelope of cupro-nickel alloy, and it leaves the muzzle of the gun with a velocity of 2000 feet per second.

The Mauser bullet is 1.21 inch long, 0.275 inch in diameter, and weighs about 175 grains. It has a steel sheath, and its muzzle velocity is 2380 feet per second.

These may be taken as the types of modern military projectiles. The trajectory is practically flat up to 500 yards. In destructive effect there is not much difference between them; they will kill up to a distance of two miles. The hard covering is employed to enable the bullet to take the grooves in the rifle, and to prevent it stripping as it passes through the barrel. It also increases the penetrating power of the missile, but diminishes its “stopping” power, unless a vital part of a long bone is struck. By removing the covering from the point of the bullet, as is done in the Dum-Dum bullet, or by splitting the end, the bullet is made to expand or “mushroom” when it strikes the body, and its stopping power is thereby greatly increased, the resulting wound being much more severe. These “soft-nosed” expanding bullets are to be distinguished from “explosive” bullets, which contain substances which detonate on impact. High-velocity conical bullets are less likely to lodge in the body than the old spherical balls. Spent shot may merely cause bruising of the surface, or they may pass through the skin and lodge in the subcutaneous tissue.

A blank cartridge fired at close range may cause a severe wound, and, if charged with black powder, may leave a permanent bluish-black pigmentation of the skin.

Effects of Small-bore Bullets on Different Tissues.—When the projectile passes through the *soft parts without striking a bone*, it makes a small round aperture at the point of entrance, and an exit wound

which is slightly if at all larger—indeed, they can scarcely be distinguished from one another. So minute are these wounds that they may readily be overlooked, especially as they rarely bleed externally. The wounds are smaller than the bullet that produces them, and their size does not appear to bear any constant relation to the range at which the weapon is fired. As a rule, no clothing or other foreign body is carried into the wound, and healing by primary union is almost invariable. The patient often feels as if he had been sharply struck with a hammer, and shock is comparatively slight, even when the abdomen is perforated. In short-range wounds there is usually considerable hæmorrhage into the subcutaneous tissues.

Shafts of Long Bones.—The effect of a small-bore bullet on the *diaphysis* of a long bone is influenced chiefly by the range at which the bullet was fired, that is, by its velocity at the moment of impact. In nearly all cases a comminuted fracture results. Lieutenant-Colonel Hickson¹ divides these fractures into three varieties: (1) the *short-range type* (up to 200 yards), in which the bullet passes through the medullary cavity at a high velocity, producing an entrance wound which is small, circular, and equal in diameter to the bullet, and an exit wound which is larger and irregular with ragged edges. The bone is so highly comminuted that several inches of its length may be pulverised, and long fissures pass into the shaft beyond. Fragments of bone may be carried out through the skin, producing secondary apertures of exit, from which fragments of muscle or tendon may protrude. Such wounds almost always become infected.

In (2)—the *medium-range type* (300 to 800 yards)—the exit wound is still larger than the entrance, but the soft parts are not lacerated to the same extent. The bone is highly comminuted, but not forced out of the tissues, neither is it broken into so many or such small fragments.

In (3)—the *long-range type* (over 900 yards)—the entrance and exit wounds tend to approximate in size. The soft parts are not injured to any marked extent. There is less tendency to complete separation of fragments, and these are few in number, although they may be large in size. The bullet often lodges in the bone or soft tissues. Suppuration does not often occur in this variety.

Cancellous Ends of Long Bones and Joints.—In some cases the bullet perforates the cancellous tissue of the epiphysis of a long bone without causing comminution or involving the adjacent joint. As a rule, however, it passes through the joint in its course, giving rise to an effusion of blood into the cavity, but without causing fissuring or comminution of the articular surfaces.

In rare cases, and particularly in the knee-joint, the bullet traverses the synovial cavity without impinging on the osseous elements. The great majority of bullet-wounds implicating joints remain aseptic, and the function of the joint is not permanently impaired.

The presence of fluid in an articulation is not pathognomonic of joint injury, as it not infrequently occurs in connection with injuries of the shaft which do not implicate the epiphysis.

Blood-vessels.—Wounds of large blood-vessels are comparatively common. They are clean-cut sections or perforations when the vessels are directly struck, and oval perforations when hit tangentially. The small-bore bullet, however, is capable of causing such damage to the walls

¹ Official Report of the Surgical Cases noted in the South African War, 1890-1902.

of an artery by the merest graze that, although no actual opening is made into it at the time, sloughing of the part of the vessel so injured takes place later, and hæmorrhage or a traumatic aneurysm is the result. If the vessel is a large one and placed superficially or in one of the cavities of the body, hæmorrhage is speedily fatal; but when the blood cannot escape externally, and collects in the tissues, it may cause sufficient tension to arrest the bleeding, and a traumatic aneurysm results (Surgeon-General Stevenson). When an artery and its accompanying vein are injured, an aneurysmal varix develops.

Bullet-wounds of *nerves* are described on p. 357.

Head Injuries.—Surgeon-General Stevenson¹ divides bullet-wounds of the head into (1) *scalp wounds with contusion of the skull*, and (2) *fractures*. The former are due to the impact of a bullet travelling at a low velocity and impinging very obliquely on the head. Even although the bone is not visibly damaged, there may be marked symptoms of concussion, and in some cases small hæmorrhages and laceration of the brain result and give rise to symptoms of irritation or of compression. In these injuries the prognosis is always favourable.

Gun-shot fractures are divided into (a) *gutter fractures*, in which a trench is ploughed through the outer table and diploë, while the inner table is comminuted, small fragments sometimes being driven through the dura.

(b) *Penetrating fractures*, in which there is only one aperture in the calvaria, and the bullet, not having sufficient impetus to carry it through the brain, lodges in it. The opening is large and irregular, and fragments of considerable size may be depressed or even driven into the brain, causing serious laceration of its substance.

(c) *Perforating fractures*, which vary in character with the range at which the weapon is discharged. At close range very serious damage is inflicted, considerable portions of the skull and brain are sometimes blown away, and death is usually immediate. Krönlien, in 1899, drew attention to the fact that the intact cerebrum may be bodily blown out of the skull. At medium and long ranges, if the bullet strikes perpendicularly to the surface, the apertures of entrance and exit are usually circular and clean-cut; if it strikes obliquely, the entrance wound is oval, with short thread-like fissures radiating from it, and the exit wound is larger and more irregular, and portions of bone may be driven outwards. In either case the inner table is more widely shattered at the aperture of entrance, and the outer table at that of exit.

In all varieties of fracture there are marked symptoms of brain injury, usually referable to the areas traversed by the bullet.

Cerebral abscess and hernia cerebri are the most common complications of gun-shot fractures.

Even in the absence of brain symptoms, all cases in which there is evidence of actual fracture of the skull require operation to admit of the wounds being purified and to permit of depressed fragments of bone being elevated or loose fragments removed. Foreign bodies lodged in the brain should be removed if easy of access, but prolonged searching for them is not permissible. The experience of the South African War showed that the results of these operations are on the whole eminently satisfactory.

Spine.—From the records of the same war it would appear that in a

¹ Official Report of the Surgical cases noted in the South African War, 1890–1902.

considerable number of cases in which the vertebræ were injured by small-bore bullets, even although the bony walls of the spinal canal had not been fractured or depressed, and no extra-dural or intra-medullary hæmorrhage had occurred, the spinal cord in the vicinity was degenerated into a "custard-like material" incapable of any conducting power (Makins). According to Stevenson, this "must have been due to the vibratory concussion communicated to it by the passage of the bullet at a high rate of velocity." The importance of this observation lies in the fact that in such cases no benefit can follow operative interference.

The cord may be partly or completely cut across by a bullet; and extra-dural and intra-medullary hæmorrhage may accompany injuries to the bones. These lesions, as well as gun-shot fractures of the vertebræ, present the same clinical features and call for the same treatment as similar injuries produced in other ways (vol. ii. chap. vi.).

Chest.—*Non-penetrating* wounds are often accompanied by fractures of ribs, sternum, or shoulder girdle, and as the projectile is frequently lodged in the tissues, sepsis is liable to ensue. External hæmorrhage is uncommon, but, even although the lung is not directly injured, hæmoptysis is often present.

In *penetrating* wounds it is often impossible to distinguish between the apertures of entrance and exit, and, even when the missile has passed through the lung, there is seldom any external hæmorrhage. In most cases these wounds run an aseptic course, and they are seldom complicated by pleurisy or pneumonia. The symptoms most frequently present are: a variable and often remarkably slight degree of shock, some cyanosis and dyspnoea, slight and transient pain, and increased rapidity of pulse-rate. Hæmoptysis is seldom a prominent symptom. Hæmothorax is the most serious complication; it is frequently accompanied by a slight degree of pneumothorax, and is usually attended with a rise of temperature even when aseptic. These lesions and their complications are treated on the same lines as when due to other forms of injury (vol. ii. chap. xx.). The removal of bullets and other foreign bodies lodged in the cavity of the thorax is only to be attempted when they are causing symptoms and can be accurately localised by the X-rays.

Wounds of the *heart* or pericardium are usually rapidly fatal, but recovery has taken place in cases in which there was every reason to believe that the heart had been perforated.

Wounds of the Abdomen.—Recent experience has demonstrated that small-bore bullets usually produce comparatively slight disturbance even when they perforate hollow as well as solid viscera; and that for such injuries the results of surgical interference are extremely disappointing. In the South African War a very large percentage of perforating abdominal wounds recovered without operation—a result which is attributed to the fact that modern bullets make very minute punctures in the intestine. As the peristalsis is arrested by the shock of the injury, nothing escapes, especially if the patient is not subjected to movement for some hours, and if, as is usually the case in active warfare, he has been fasting for some time before being wounded. The punctures in the gut have therefore time to become occluded by peritoneal adhesions before the intestinal contents pass along the injured segment.

The passage of a small-bore bullet through a *solid viscus*—such as the liver, spleen, pancreas, or kidney—produces comparatively little laceration; hence there is little or no bleeding, and few symptoms of any moment ensue.

Operations performed on the field are contra-indicated in abdominal injuries, as they are calculated to prevent the formation of the adhesions which naturally close the perforations, or to break down such as have occurred.

Shell Wounds and Wounds produced by Explosions.—It is convenient to consider together the effects of the bursting of shells fired from heavy ordnance in warfare, and those resulting in the course of blasting operations from the discharge of dynamite or other explosives, or from the bursting of steam boilers or pipes, the breaking of machinery, and similar accidents met with in civil practice.

Two types of shell are used by artillery: the *common shell*, which consists of a hollow metal cylinder containing a bursting charge of powder, discharged either by a time-fuse or by impact; and *Shrapnel shell*, the cavity of which contains several hundred large round bullets, which are dispersed by the bursting of the shell, this being timed to take place from 50 to 100 yards in front of the enemy. The destructive effect is produced by the fragments into which the shell bursts, together with, in the case of Shrapnel the shower of bullets thus set free.

Wounds inflicted by shell fragments and Shrapnel bullets tend to be extensive in area, but they do not penetrate deeply, and they show great contusion, laceration, and destruction of the tissues implicated. Owing to their comparatively low velocity, the missiles frequently lodge in the tissues. Shell wounds are attended with a considerable degree of shock. On account of the wide area of contusion which surrounds the actual wound produced by shell fragments, amputation, when called for, should be performed some distance above the torn tissues, and the prognosis in all cases should be guarded, as there is considerable risk of sloughing of the flaps. Unlike the wounds produced by small-bore bullets, those resulting from shell fragments comparatively seldom run an aseptic course.

Wounds produced by dynamite explosions, the bursting of boilers, and the breaking of machinery have the same general characters as shell wounds. Fragments of stone, coal, or metal may lodge in the tissues, and if infected cause septic complications.

All such injuries are to be treated on the general principles governing contused and lacerated wounds.

Foreign Bodies embedded in the Tissues.—Foreign bodies may enter and lodge in the tissues accidentally, or they may be intentionally placed there in the course of an operation. In

gun-shot and punctured wounds, for example, it is not uncommon for bullets, fragments of clothing, portions of knife-blades or spikes, to lodge in the wound ; and needles, splinters of wood, and other sharp objects frequently pierce the skin, and remain embedded in the deeper parts. As a result of explosions, also, particles of carbon, in the form of coal-dust or gunpowder or portions of shale, may lodge in a wound or in the adjacent skin.

The foreign substances most frequently left in a wound in the course of an operation are portions of catgut, silk, or linen thread used as ligatures or sutures ; silver wire, aluminium or steel plates or ivory pegs used to secure bones which have been divided or fractured ; and solid paraffin introduced to correct deformities.

Irrespective of its mode of entrance, the foreign body at first acts as an irritant, and induces a reaction in the tissues in which it lodges, in the form of hyperæmia, local leucocytosis, proliferation of fibroblasts, and the formation of granulation tissue. The subsequent changes depend upon whether or not the wound is infected with pyogenic bacteria. If it is so infected, suppuration ensues, a sinus forms, and persists until the foreign body is either cast out or removed.

If the wound is aseptic, the fate of the foreign body varies with its character. Substances that are absorbable, such as catgut or fine silk, are surrounded and permeated by the phagocytes, which soften and disintegrate them, the debris being gradually absorbed, in very much the same manner as a fibrinous exudate. Minute bodies that are not capable of being absorbed, such as particles of carbon, or of pigment used in tattooing, are taken up by the phagocytes, and in course of time removed. Larger bodies, such as needles or bullets, which are not capable of being destroyed by the phagocytes, become encapsulated. In the granulation tissue by which they are surrounded large multi-nuclear giant-cells appear (*foreign-body giant-cells*), and attach themselves to the foreign body, the fibroblasts proliferate, and a capsule of scar tissue is eventually formed around the body. The tissues of the capsule may show evidence of iron pigmentation. Sometimes fluid accumulates around a foreign body within its capsule, constituting a cyst. When a foreign body lodges in a space, such as a joint or bursa, or in non-vascular tissue, no capsule forms round it.

Substances like paraffin, strands of silk used to bridge a gap in a tendon, or portions of calcined bone, instead of being

encapsulated, are gradually permeated and eventually replaced by new connective tissue.

Embedded bodies may remain in the tissues for an indefinite period without giving rise to inconvenience. At any time, however, they may cause trouble, either as a result of septic complications, or by inducing the formation of a mass of inflammatory tissue around them, which may simulate a gumma, a tuberculous focus, or a sarcoma. This latter condition may give rise to difficulties in diagnosis, particularly if there is no history forthcoming of the entrance of the foreign body. In such cases the X-rays will reveal the presence of the foreign body if it is sufficiently opaque to cast a shadow. The heavy, lead-containing varieties of glass throw very definite shadows little inferior in sharpness and definition to those of metal; almost all the ordinary forms of commercial glass also may be shown up with the ordinary application of the X-rays.

The question of removal of the foreign body must be decided according to the conditions present in individual cases.

BURNS AND SCALDS

A burn results from the action of dry heat on the tissues of the body; and a scald from the action of moist heat. This distinction, however, has no clinical importance.

Burns are most frequently produced by flames—as, for example, when a child's clothes catch fire; by gas, paraffin, or gunpowder explosions; or by contact with molten metal or hot solids. Electricity and the Röntgen rays also produce lesions of the nature of burns. Scalding is usually due to contact with boiling fluids, or to the escape of steam in boiler explosions. In young and debilitated subjects hot poultices may produce similar injuries.

It is an interesting fact that in old people with enfeebled circulation mere exposure to a strong fire may produce severe degrees of burning, the clothes covering the part being uninjured. This may also occur about the feet, legs, or knees of persons who have fallen asleep before the fire while intoxicated.

The damage done to the tissues by strong caustics, such as fuming nitric acid, sulphuric acid, caustic potash, nitrate of silver, or arsenical paste, presents pathological and clinical features almost identical with those resulting from heat.

Pathology of Burns.—Much discussion has taken place regarding the explanation of the rapidly fatal issue in extensive

superficial burns. On post-mortem examination the lesions found in these cases are: (1) general hyperæmia of all the organs of the abdominal, thoracic, and cerebro-spinal cavities; (2) marked leucocytosis, with destruction of red corpuscles, setting free hæmoglobin which lodges in the epithelial cells of the tubules of the kidneys; (3) minute thrombi and extravasations throughout the tissues of the body; (4) degeneration of the ganglion cells of the solar plexus; (5) œdema and degeneration of the lymphoid tissue throughout the body; (6) cloudy swelling of the liver and kidneys, and softening and enlargement of the spleen. Bardeen suggests that these morbid phenomena correspond so closely to those met with where the presence of a toxin is known to produce them, that in all probability death is similarly due to the action of some poison, the source and nature of which are as yet unknown.

Clinical Features.—Local Phenomena.—The most generally accepted classification of burns is that of Dupuytren, which is based upon the depth of the lesion. Six degrees are thus recognised: (1) hyperæmia or erythema; (2) vesication; (3) partial destruction of the true skin; (4) total destruction of the true skin; (5) charring of muscles; (6) charring of bones.

It must be observed, however, that burns met with at the bedside always illustrate more than one of these degrees, the deeper forms always being associated with those less deep, and the clinical picture is made up of the combined characters of all. A burn is classified in terms of its most severe portion. It is also to be remarked that the extent and severity of a burn usually prove to be greater than at first sight appears.

Burns of the First Degree are associated with erythema of the skin, due to hyperæmia of its blood-vessels, and result from scorching by flame, from contact with solids or fluids below 212° F., or from exposure to the sun's rays. They are characterised clinically by acute pain, redness, transitory swelling from œdema, and subsequent desquamation of the surface layers of the epidermis.

Burns of Second Degree—Vesication of the Skin.—These are characterised by the occurrence of vesicles or blisters which are scattered over the hyperæmic area, and contain a clear yellowish or brownish fluid. On removing the raised epidermis, the congested and highly sensitive papillæ of the skin are exposed. Unna has found that pyogenic bacteria are invariably present in these blisters. Burns of the second degree leave no permanent scar but frequently a persistent discoloration. In

rare instances the burned area becomes the seat of a peculiar overgrowth of fibrous tissue, known as keloid.

Burns of Third Degree—Partial Destruction of the True Skin.—The epidermis and papillæ are destroyed in patches, leaving hard, dry, and insensitive sloughs of a yellow or black colour. The pain in these burns is intense, but passes off during the first or second day, to return again, however, when, about the end of a week, the sloughs separate and expose the nerve filaments of the underlying skin. Granulations spring up to fill the gap, and are rapidly covered by epithelium, derived partly from the margins and partly from the remains of skin glands which have not been completely destroyed. These latter appear on the surface of the granulations as small bluish islets which gradually increase in size, become of a greyish-white colour, and ultimately blend with one another, and with the edges. The resulting cicatrix may be slightly depressed, but otherwise exhibits little tendency to contract and cause deformity.

Burns of Fourth Degree—Total Destruction of the True Skin.—These follow the prolonged application of any form of intense heat. Large, black, dry eschars are formed, surrounded by a zone of intense congestion. Pain is less severe, and is referred to the parts that have been burned to a less degree. Septic infection is very liable to result and to lead to wide destruction of the surrounding skin. The amount of granulation tissue necessary to fill the gap is therefore great; and as the epithelial covering can only be derived from the margins—the skin glands being completely destroyed—the healing process is slow. The resulting scars are irregular, deep and puckered, and show a great tendency to contract. Keloid frequently develops in such cicatrices. When situated in the region of the face, neck, or flexures of joints, much deformity and impairment of function may result (Fig. 61).

In *burns of the fifth degree* the lesion extends through the subcutaneous tissue and involves the muscles; while in those of the *sixth degree* it passes still more deeply and implicates the bones. These burns are comparatively limited in area, as they are usually produced by prolonged contact with hot metal or caustics. Burns of the fifth and sixth degrees are sometimes met with in epileptics who fall into the fire during a fit. Large blood-vessels, nerve-trunks, joints, or serous cavities may be implicated.

General Phenomena.—It is customary to divide the clinical history of a severe burn into three periods; but it is to be

observed that the features characteristic of the periods have been greatly modified since burns have been treated on the same lines as other wounds.

The *first period* lasts for from thirty-six to forty-eight hours, during which time the patient remains in a more or less profound state of shock, and there is a remarkable absence of pain. When shock is absent or little marked, however, the amount of suffering may be very great. When the injury proves fatal during this period, death is due to shock, probably aggravated by the absorption of poisonous substances produced in the burned tissues. In fatal cases there is often evidence of cerebral congestion and oedema.

The *second period* begins when the shock passes off, and lasts till the sloughs separate. The outstanding features of this period are fever, the temperature rising to 102° ,

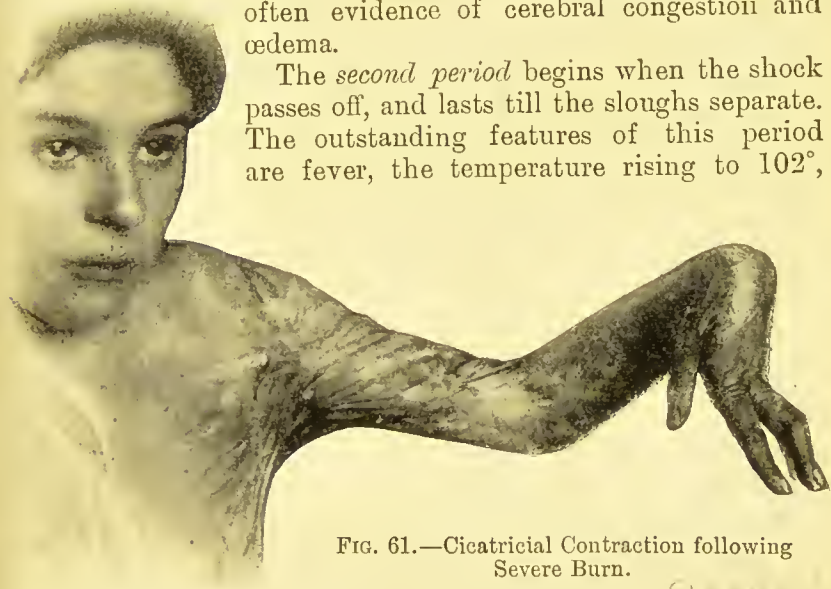


FIG. 61.—Cicatricial Contraction following Severe Burn.

103° or 104° F.; and congestive or inflammatory conditions of internal organs, giving rise to such clinical complications as bronchitis, broncho-pneumonia, or pleurisy—especially in burns of the thorax; or meningitis and cerebritis, when the neck or head is the seat of the burn. Intestinal catarrh associated with diarrhoea is not uncommon; and ulceration of the duodenum leading to perforation has been met with in a few cases. These phenomena are much more prominent when septic infection has taken place, and it seems probable that they are all to be attributed to the infection, as they have become less frequent and less severe since burns have been treated on antiseptic principles. Albuminuria is a fairly constant symptom in severe burns, and is probably due to congestion of the kidneys. In

burns implicating the face, neck, mouth, or pharynx, œdema of the glottis is a dangerous complication, entailing as it does the risk of suffocation.

The *third period* begins when the sloughs separate, usually between the seventh and fourteenth days, and lasts till the wound heals, its duration depending upon the size, depth, and asepticity of the raw area. The chief causes of death during this period are septic absorption in any of its forms; waxy disease of the liver, kidneys, or intestine; less commonly erysipelas, tetanus, or other diseases due to infection by specific organisms. It is stated that duodenal ulcers have sometimes perforated and caused death during the third period.

The *prognosis* in burns depends on (1) the superficial extent, and, to a much less degree, the depth of the injury. When more than one-third of the entire surface of the body is involved, even in a mild degree, the prognosis is grave. (2) The situation of the burn is important. Burns over the serous cavities—abdomen, thorax, or skull—are, other things being equal, much more dangerous than burns of the limbs. The risk of œdema of the glottis in burns about the neck and mouth has already been referred to. (3) Children are more liable to succumb to shock during the early periods, but withstand prolonged suppuration better than adults. (4) When the patient survives the shock, the presence or absence of sepsis is the all-important factor in prognosis.

Treatment.—The *general treatment* consists in combating the shock (p. 262). When pain is severe, morphin must be injected.

Local Treatment.—After the shock has passed off, the local treatment must be carried out on antiseptic lines, a general anæsthetic being administered, if necessary, to enable the purification to be carried out thoroughly. After carefully removing the clothing, the whole of the burned area is gently, but thoroughly, washed with a mild antiseptic lotion, such as warm boracic or biniodide of mercury, followed by sterilised saline solution. As pyogenic bacteria are invariably found in the blisters of burns, these must be opened and the raised epithelium removed.

The dressings subsequently applied should meet the following indications: the relief of pain; the prevention of sepsis; and the promotion of cicatrisation.

The application which most satisfactorily fulfils these requirements is *picric acid*, which is applied to the surface as a watery

solution—made up of picric acid, $1\frac{1}{2}$ drams; absolute alcohol, 3 ounces; distilled water, 40 ounces.

Pads of lint or gauze are lightly wrung out of the solution and applied over the whole of the reddened area. These are covered with antiseptic wool, *without* any waterproof covering, and retained in position by a many-tailed bandage. The injured part should be kept at rest by a splint or other suitable appliance. The dressing should be changed once or twice a week, any portion of the original dressing which remains perfectly dry being left undisturbed. The value of a general anæsthetic in dressing extensive burns, especially in children, can scarcely be overestimated.

Picric acid yields its best results in the more superficial burns, and it is useful as a *primary dressing* in all. As soon as the sloughs separate and a granulating surface forms, the ordinary treatment for a healing sore is instituted. Any slough under which pus has collected should be cut away with scissors to permit of free drainage.

An alternative method of treating extensive burns is by immersing the part, or even the whole body when the trunk is affected, in a bath of boracic lotion kept at the body temperature, the lotion being frequently renewed.

When a burn is already septic when first seen by the surgeon, it is to be treated on the same principles as govern the treatment of other infected wounds.

All moist or greasy applications, such as Carron oil, carbolic oil and ointments, and all substances like collodion and dry powders, which retain discharges, entirely fail to meet the indications for the rational treatment of burns, and should be abandoned.

Skin-grafting is of great value in hastening healing after extensive burns, and in preventing cicatricial contraction. The *deformities* which are so liable to develop from contraction of the cicatrices resulting from burns are treated on the general principles governing plastic operations. In the region of the face, neck, and flexures of joints (Fig. 61), where they are most marked, the contracted bands may be divided and the parts stretched, the raw surface left being covered by Thiersch grafts or by flaps of skin raised from adjacent surfaces and glided or twisted into position.

INJURIES PRODUCED BY ELECTRICITY

Lesions of the nature of burns result from the action of electricity on the tissues. They differ sufficiently from ordi-

nary burns to merit separate description, and may be considered under the headings of (1) injuries produced by exposure to the Röntgen rays, (2) electrical burns, and (3) lightning-stroke.

Injuries produced by Exposure to the Röntgen Rays.—It would appear that these injuries only follow exposure to electric discharges emanating from a Crooke's tube; that the patient experiences no sensation of electric shock or of heat; and that prolonged or repeated exposure is usually necessary to their production. Owing to the systematic use of shields, the shorter exposures employed, and the improved technique generally, these injuries are now comparatively rare.

Two distinct varieties of X-ray burn are recognised—an erythematous form, resembling a superficial burn; and an ulcerative and sloughing form, corresponding to a burn of the third or fourth degree.

The *erythematous* form—described as *X-ray dermatitis*—is usually met with on the back of the hands and fingers of those who work with the Röntgen apparatus, but occasionally occurs in patients who have been subjected to the rays for diagnostic or therapeutic purposes. The first symptom is the appearance of a red patch on the skin, attended with itching, but devoid of pain. This seldom appears sooner than two or three weeks after the exposure. The skin becomes dry, tends to crack, and finally desquamates; the hairs are lost; the nails become brittle; and the sense of touch is sometimes impaired. The condition is very persistent, and usually lasts for several months. It disappears spontaneously, but it is liable to recur if the parts are again exposed to the influence of the rays, and may in course of time be followed by the development of X-ray cancer. In some cases the only effect of the rays is to destroy the hair on the exposed part; it may begin to grow again in a few weeks, or the loss may be permanent.

The *ulcerative* form is met with in patients subjected to the rays for a prolonged period, and usually begins within a week of the exposure, although in some cases the first signs have been delayed for two or three weeks. The onset is marked by redness of the skin and slight pain. In a few days a blister containing sero-purulent fluid rises, and after bursting leaves a raw surface which is extremely painful. A slough slowly forms and gradually increases in size, spreading through the deep fasciæ and exposing the muscle. The prominent features of this form are the extreme slowness with which the sloughs separate,—the process sometimes occupying several months,—and the severity of the pain, which usually calls for the admini-

stration of opiates. The raw surface left after the separation of the slough is very slow to heal, and during the process fresh patches of necrosis may appear.

The treatment is carried out on the same lines as in other forms of burns. Recovery may be hastened by excising the slough and applying Thiersch grafts over the raw area, when this is practicable.

Electrical burns usually occur in those who are engaged in industrial undertakings where powerful electrical currents are employed.

The lesions—which vary from a slight superficial scorching to complete charring of parts—are most evident at the points of entrance and exit of the current, the intervening tissues apparently escaping injury.

The more superficial degrees of electrical burns differ from those produced by heat in being almost painless, and in healing very slowly, although as a rule they remain dry and aseptic.

The more severe forms are attended with a considerable degree of shock, which is not only more profound, but also lasts much longer than the shock in an ordinary burn of corresponding severity. The parts at the point of entrance of the current are charred to a greater or less depth. The eschar is at first dry and crisp, and is surrounded by a zone of pallor. For the first thirty-six to forty-eight hours there is comparatively little suffering, but at the end of that time the parts become exceedingly painful. In a majority of cases, in spite of careful purification, a slow form of moist gangrene sets in, and the slough spreads both in area and in depth, until the muscles and often the large blood-vessels and nerves are exposed. A line of demarcation eventually forms, but the sloughs are exceedingly slow to separate, taking from three to five times as long as in an ordinary burn, and during the process of separation there is considerable risk of secondary hæmorrhage from erosion of large vessels.

Treatment.—Electrical burns are treated on the same lines as ordinary burns, by thorough purification and the application of dry dressings, with a view to avoiding the onset of moist gangrene. After granulations have formed, skin-grafting is of great value in hastening healing.

Lightning-stroke.—In a large proportion of cases lightning-stroke proves instantly fatal. In non-fatal cases the patient suffers from a profound degree of shock, and there may or may not be any external evidence of injury. In the mildest cases red spots or wheals—closely resembling those of urticaria—may

appear on the body, but they usually fade again in the course of twenty-four hours. Sometimes large patches of skin are scorched or stained, the discoloured area showing a markedly arborescent appearance. In other cases the injured skin becomes dry and glazed, resembling parchment. Appearances are occasionally met with corresponding to those of a superficial burn produced by heat. The chief difference from ordinary burns is the extreme slowness with which healing takes place. Localised paralysis of groups of muscles, or even of a whole limb, may follow any degree of lightning-stroke. Treatment is mainly directed towards combating the shock, the surface lesions being treated on the same lines as ordinary burns.

CHAPTER XIII

CONSTITUTIONAL EFFECTS OF INJURIES

SYNCOPE — SHOCK — COLLAPSE—DELIRIUM IN SURGICAL PATIENTS :
Delirium in general; Delirium Tremens; Traumatic Delirium—
FAT EMBOLISM.—TRAUMATIC ASPHYXIA.

SYNCOPE, SHOCK, AND COLLAPSE

SYNCOPE, shock, and collapse are clinical conditions which, although depending on different causes, bear a superficial resemblance to one another. Syncope is essentially due to a sudden cerebral anæmia; shock to a reflex paralysis of the vaso-motor centre in the medulla; and collapse to abstraction of fluids from the tissues and the blood.

Syncope or Fainting.—Syncope is the result of a suddenly produced anæmia of the brain from temporary weakening or arrest of the heart's action. In surgical practice, this condition is usually observed in nervous persons who have been subjected to pain, as in the reduction of a dislocation or the incision of a whitlow; or in those who have rapidly lost a considerable quantity of blood. It may also follow the sudden withdrawal of fluid from a large cavity, as in tapping an abdomen for ascites, or withdrawing fluid from the pleural cavity. Syncope sometimes occurs also during the administration of chloroform, especially if there is a tendency to sickness and the patient is not completely under. During an operation the onset of syncope is often recognised by the cessation of oozing from the divided vessels before the general symptoms become manifest.

Clinical Features.—When a person is about to faint he feels giddy, has surging sounds in the ears, and haziness of vision; he yawns, becomes pale and sick, and a free flow of saliva takes place into the mouth. The pupils dilate; the pulse becomes small and almost imperceptible; the respirations shallow and hurried; consciousness gradually fades away, and he falls in a heap on the floor.

Sometimes vomiting ensues before the patient completely loses consciousness, and the muscular exertion entailed may ward off the actual faint. This is frequently seen in threatened syncopal attacks during chloroform administration.

Recovery begins in a few seconds, the patient sighing or gasping, or, it may be, vomiting; the strength of the pulse gradually increases, and consciousness slowly returns. In some cases, however, syncope is fatal.

Treatment.—The head should at once be lowered—in imitation of nature's method—to encourage the flow of blood to the brain, the patient, if necessary, being held up by the heels. All tight clothing, especially round the neck or chest, must be loosened. The heart may be stimulated reflexly by dashing cold water over the face or chest, or by rubbing the face vigorously with a rough towel. The application of volatile substances, such as ammonia or smelling-salts, to the nose; the administration by the mouth of sal-volatile, whisky or brandy, and the intra-muscular injection of ether, are the most speedily efficacious remedies. In severe cases the application of hot cloths over the heart, or of the faradic current over the line of the phrenic nerve, just above the clavicle, may be called for.

Surgical Shock.—This term is applied to a condition in which there is a profound lowering of the vital activity, resulting from inhibition or exhaustion of the vaso-motor mechanism, and associated with marked lowering of the blood pressure.

The most important factor in the production of surgical shock is mechanical injury, as a result of which powerful afferent impulses pass to the central nervous system, and the more highly the injured part is endowed with sensory nerves the more marked is the shock. A crush of the hand, for example, is attended with a more intense degree of shock than a correspondingly severe crush of the foot; and injuries of such specially innervated parts as the testis, the urethra, the face, the spinal cord, or the brain, are associated with severe degrees. as are also those of parts innervated from the sympathetic system, such as the abdominal or thoracic viscera.

Among the factors which contribute to produce shock, or to intensify it, are loss of blood, exposure to cold, pain, and septic intoxication. Disease of the kidneys or of the heart and blood-vessels, and the cachexia associated with malignant disease, are predisposing causes. The aged frequently manifest but few signs of shock, but have a correspondingly feeble power of recovery; and while many young children suffer little,

even after severe operations, others with much less cause succumb to the shock.

Intense mental emotion, with or without mechanical injury, may be followed by shock, and persons with a highly strung nervous system are more prone to suffer than those of a more phlegmatic temperament.

When the injured person's mind is absorbed with other matters than his own condition,—as, for example, during the heat of a battle or in the excitement of a railway accident or a conflagration,—even severe injuries may be unattended by pain or shock at the time, although when the period of excitement is over the severity of the shock is all the greater. The same thing is observed in persons injured while under the influence of alcohol.

The explanation of shock usually accepted, largely on the authority of Crile and Mummery, is that the paralysis or exhaustion of the vaso-motor centre in the medulla results in a lessening of the vascular tone, particularly that of the arteries, and a marked fall in the blood pressure. Most of the blood leaves the arteries and collects in the large venous trunks, especially those of the abdomen, and there is thus produced an anæmia of the brain and of the superficial parts of the body. At the same time the right side of the heart becomes overloaded, and impeded in its action. According to J. D. Malcolm, the disturbance of the vaso-motor centre results, not in dilatation, but in contraction of the arteries. At first the superficial vessels are constricted, and, if the exciting cause is kept up, this condition spreads back to the larger vessels, so that the blood is driven out into the tissues and back into the abdominal veins.

Clinical Features.—The patient is in a state of great prostration. He is roused from his condition of indifference with difficulty, but answers questions intelligently, if only in a whisper. The face is pale, beads of sweat stand out on the brow, the features are drawn, the eyes sunken, and the cheeks hollow. The lips and ears are pallid; the skin of the body of a greyish colour, cold, and clammy. The pulse is rapid, fluttering, and often all but imperceptible at the wrist; the respiration is irregular, shallow, and sighing; and the temperature may fall to 96° F. or even lower. The mouth is parched, and the patient complains of thirst. There is little sensibility to pain, and for purposes of operation very little anæsthetic is required to render the patient unconscious.

Except in very severe cases, shock tends towards recovery

within a few hours, the *reaction*, as it is called, being often ushered in by vomiting. The colour improves; the pulse becomes full and bounding; the respiration deeper and more regular; the temperature rises to 100° F. or higher; and the patient begins to take notice of his surroundings.

In certain cases the symptoms of shock so closely resemble those resulting from septic intoxication, that it is difficult, if not impossible to distinguish between them, and there can be little doubt that many deaths have been attributed to shock which were really due to acute septicæmia. The conditions formerly known as "delayed shock" and "prostration with excitement" are now generally recognised to be due to septic poisoning.

Question of Operating during Shock.—Most authorities agree that operations should only be undertaken during profound shock when they are imperatively demanded for the arrest of hæmorrhage, the prevention of septic infection of serous cavities, or for the relief of pain which is producing or intensifying the condition.

Prevention of Operation Shock.—In the preparation of a patient for operation, drastic purgation and prolonged fasting must be avoided, and about half an hour before a prolonged and severe operation a pint of saline solution should be slowly introduced into the rectum; and this is repeated, if necessary, during the operation, and at its conclusion. The operating-room must be warm—not less than 70° F.—and the patient should be wrapped in cotton wool and blankets, and surrounded by hot-bottles. All lotions used must be warm (100° F.); and the operation should be completed as speedily and as bloodlessly as possible. With a view to preventing the passage of exciting afferent impulses, Crile advocates "blocking" of the nerves, by the injection of a 1 per cent. solution of novocaine into their substance on the proximal side of the field of operation. In selecting an anæsthetic, it may be borne in mind that chloroform lowers the blood pressure more than ether does, and that with spinal anæsthesia there is no lowering of the blood pressure.

Treatment.—A patient suffering from shock should be placed in the recumbent position, with the foot of the bed raised to facilitate the return circulation in the large veins, and so to increase the flow of blood to the brain. His bed should be placed near a large fire, and the patient himself surrounded by cotton wool and blankets and hot-bottles. If he has lost much blood, the limbs should be wrapped in cotton wool

and firmly bandaged from below upwards, to conserve as much of the circulating blood as possible in the trunk and head. As soon as he has been put to bed, about a pint of saline solution should be introduced into the rectum, and ten to fifteen minims of adrenalin chloride (1 in 1000) may with advantage be added to the fluid. The injection should be repeated every two hours until the circulation is sufficiently restored. Recent investigations seem to indicate that such cardiac stimulants as strychnin, digitalin, or strophanthin are contra-indicated in shock, as they merely exhaust the already impaired vaso-motor centre.

Artificial respiration may be useful in tiding a patient over the critical period of shock, especially at the end of a severe operation.

The introduction of saline solution at a temperature of about 105° F. into a vein or into the subcutaneous tissue is most useful where much blood has been lost (p. 285). Two or three pints may be injected into the veins, or smaller quantities under the skin.

The extreme thirst of which the patient so often complains is best met by giving small quantities of warm water by the mouth, or by the introduction of saline solution into the rectum. Ice only relieves thirst for a short time, and as it is liable to induce flatulence should be avoided, especially in abdominal cases. Dryness of the tongue may be relieved by swabbing the mouth with a mixture of glycerin and lemon juice.

If severe pain calls for the use of morphin, $\frac{1}{120}$ th grain of atropin should be added, or heroin alone may be given in doses of $\frac{1}{24}$ th grain.

Collapse is a clinical condition which comes on more insidiously than shock, and which does not attain its maximum degree of severity for several hours. It is met with in the course of severe illnesses, especially such as are associated with the loss of large quantities of fluid from the body—for example, by severe diarrhoea, notably in Asiatic cholera; by persistent vomiting; or by profuse sweating, as in some cases of heat-stroke. Severe degrees of collapse follow any sudden and profuse loss of blood.

Collapse often follows upon shock—for example, in intestinal perforations, or after abdominal operations complicated by peritonitis, especially if there is vomiting, as in cases of obstruction high up in the intestine. The symptoms of collapse are aggravated if septic absorption is superadded to the loss of fluid.

The *clinical features* of this condition are practically the same as those of shock ; and it is treated on the same lines.

DELIRIUM IN SURGICAL PATIENTS

Delirium is a temporary disturbance of mind which occurs in the course of certain diseases, and sometimes after injuries. It is to be looked upon as a serious and dangerous complication.

The causes of delirium in surgical patients are numerous, and it is not always easy in a given case to discover the cause. Thus, for example, it may be associated with any of the acute pyogenic infections ; with erysipelas, especially when it affects the head or face ; or with chronic septic diseases of the urinary organs. In the various forms of meningitis also, and in some cases of injury to the head, it is common ; and it is sometimes met with after severe hæmorrhage, and in cases of poisoning by such drugs as iodoform, cocain, or alcohol. Delirium may also, of course, be a symptom of insanity.

Often there is merely incoherent muttering regarding past incidents or occupations, or about absent friends ; or the condition may assume the form of excitement, of dementia, or of melancholia ; and the symptoms are usually worst during the night.

Delirium Tremens is seen in persons addicted to alcohol, who, as a result of accident or operation, are suddenly compelled to lie in bed for some time. Although oftencst met with in habitual drunkards or chronic tipplers, it is by no means uncommon in moderate drinkers, and has even been seen in children.

Clinical Features.—The delirium, which has been aptly described as being of a “busy” character, usually first manifests itself within a few days of the patient being laid up. For two or three days he refuses food, is depressed, suspicious, sleepless and restless, desiring to be allowed out of bed. Then he begins to mutter incoherently, to pull off the bed-clothes, and to attempt to get out of bed. There is general muscular tremor, most marked in the tongue, the lips, and the hands. The patient imagines that he sees all sorts of horrible beings around him, and is sometimes greatly distressed because of rats, mice, beetles, or snakes which he fancies are crawling over him. The pulse is soft, rapid, and compressible ; the temperature is only moderately raised (100° – 101° F.), and as a rule there is profuse sweating. The digestion is markedly impaired, and there is often vomiting. Patients in this condition are

peculiarly insusceptible to pain, and may even walk about with a fractured leg without apparent discomfort.

In most cases the symptoms begin to pass off in three or four days; the patient sleeps, the hallucinations and tremors cease, and he gradually recovers. In other cases the temperature rises, the pulse becomes very rapid, and death results from exhaustion.

The main indication in *treatment* is to secure sleep, and this is done by the administration of bromides, chloral, or paraldehyde, or of one or other of the drugs of which sulphonal, trional, and veronal are examples. Heroin in doses of from $\frac{1}{24}$ th to $\frac{1}{12}$ th grain is often of great service. Morphin must be used with great caution. In some cases hyoscin ($\frac{1}{200}$ grain) injected hypodermically is found efficacious when all other means have failed, but this drug must be used with great discrimination. The patient must be encouraged to take plenty of easily digested fluid food, supplemented, if necessary, by nutrient enemata and saline infusions.

In the early stage a brisk mercurial purge is often of value. Alcohol should be withheld, unless failing of the pulse strongly indicates its use, and then it should be given in the food.

A delirious patient must be constantly watched by a trained attendant or other competent person, lest he get out of bed and do harm to himself or others. Mechanical restraint is often necessary, but must be avoided if possible, as it is apt to increase the excitement and exhaust the patient. On account of the extreme restlessness, there is often great difficulty in carrying out the proper treatment of the primary surgical condition, and considerable modifications in splints and other appliances are often rendered necessary.

A form of delirium, sometimes spoken of as **Traumatic Delirium**, may follow on severe injuries or operations in persons of neurotic temperament, or in those whose nervous system is exhausted by overwork. It is met with apart from alcoholic intemperance. This form of delirium seems to be specially prone to ensue on operations on the face, the thyroid gland, or the genito-urinary organs. The symptoms appear in from two to five days after the operation, and take the form of restlessness, sleeplessness, low incoherent muttering, and picking at the bed-clothes. It is not necessarily attended by fever or by muscular tremors. The patient may show hysterical symptoms. This condition is probably to be regarded as a form of insanity, as it is liable to merge into mania or melancholia.

The *treatment* is carried out on the same lines as that of delirium tremens.

Fat Embolism.—After various injuries and operations, but especially such as implicate the marrow of long bones—for example, comminuted fractures, osteotomies, resections of joints, or the forcible correction of deformities—fluid fat may enter the circulation in variable quantity. In the vast majority of cases no ill effects follow, but when the quantity is large or when the absorption is long continued certain symptoms ensue, either immediately, or more frequently not for two or three days. These are mostly referable to the lungs and brain.

In the lung the fat collects in the minute blood-vessels and produces venous congestion and œdema, and sometimes pneumonia. Dyspnœa, with cyanosis, a persistent cough and frothy or blood-stained sputum, a feeble pulse and low temperature, are the chief symptoms.

When the fat lodges in the capillaries of the brain, the pulse becomes small, rapid, and irregular, delirium followed by coma ensues, and the condition is usually rapidly fatal.

Fat is usually to be detected in the urine, even in mild cases.

The *treatment* consists in tiding the patient over the acute stage of his illness, until the fat is eliminated from the blood-vessels.

Traumatic Asphyxia or Traumatic Cyanosis.—This term has been applied to a condition which results when the thorax is so forcibly compressed that respiration is mechanically arrested for several minutes. It has occurred from the patient being crushed in a struggling crowd, or under a fall of masonry, and in machinery accidents. When the patient is released, the face and the neck as low down as the level of the clavicles present an intense discoloration, varying from deep purple to blue-black. The affected area is very sharply defined, and on close inspection the appearance is found to be due to the presence of countless minute reddish-blue or black spots, with small areas or streaks of normal skin between them. The punctate nature of the discoloration is best recognised towards the periphery of the affected area—at the junction of the brow with the hairy scalp, and where the dark patch meets the normal skin of the chest (Beach and Cobb). Pressure over the skin does not cause the colour to disappear as in ordinary cyanosis. It has been shown by Wright of Boston, that the discoloration is due to stasis from mechanical over-distension of the veins and capillaries, and actual extravasation into the tissues is exceptional. The sharply defined distribution of the discoloration is attributed to the absence of functioning

valves in the veins of the head and neck, so that when the increased intra-thoracic pressure is transmitted to these veins they become engorged. Under the conjunctivæ there are extravasations of bright red blood; and sublingual hæmatoma has been observed (Beatson).

The discoloration begins to fade within a few hours, and



FIG. 62.—Traumatic Asphyxia.

(From a photograph lent by Sir George T. Beatson.)

after the second or third day it rapidly disappears, without showing any of the chromatic changes which characterise the disappearance of a bruise. The sub-conjunctival ecchymosis, however, persists for several weeks and disappears like other extravasations. Apart from combating the shock, or dealing with concomitant injuries, no treatment is called for.

CHAPTER XIV

THE BLOOD-VESSELS

Anatomy—INJURIES OF ARTERIES: *Varieties*—INJURIES OF VEINS: *Air Embolism*—Repair of Blood-vessels and natural arrest of hæmorrhage—HÆMORRHAGE: *Varieties*; *Prevention*; *Arrest*—Constitutional effects of hæmorrhage—Hæmophilia—DISEASES OF BLOOD-VESSELS: Thrombosis; Embolism—Arteritis: *Varieties*; Atheroma—Thrombo-phlebitis—Phlebitis: *Varieties*—VARIX—ANGIOMATA—Nævus: *Varieties*; *Electrolysis*—Cirroid Aneurysm—ANEURYSM: *Varieties*; *Methods of Treatment*—ANEURYSMS OF INDIVIDUAL ARTERIES.

Surgical Anatomy.—An *artery* has three coats: an internal coat—the *tunica intima*—made up of a single layer of endothelial cells lining the lumen; outside of this a layer of delicate connective tissue; and still farther out a dense tissue composed of longitudinally arranged elastic fibres—the internal elastic lamina. The *tunica intima* is easily ruptured. The middle coat, or *tunica media*, consists of non-stripped muscular fibres, arranged for the most part concentrically round the vessel. In this coat also there is a considerable proportion of elastic tissue, especially in the larger vessels. The thickness of the vessel wall depends chiefly on the development of the muscular coat. The external coat, or *tunica adventitia*, is composed of fibrous tissue, containing, especially in vessels of medium calibre, some yellow elastic fibres in its deeper layers.

In most parts of the body the arteries lie in a sheath of connective tissue, from which fine fibrous processes pass to the *tunica adventitia*. The connection, however, is not a close one, and the artery when divided transversely is capable of retracting for a considerable distance within its sheath. In some of the larger arteries the sheath assumes the form of a definite membrane.

The arteries are nourished by small vessels—the *vasa vasorum*—which ramify chiefly in the outer coat. They are also well supplied with nerves, which regulate the size of the lumen by inducing contraction or relaxation of the muscular coat.

The *veins* are constructed on the same general plan as the arteries, the individual coats, however, being thinner. The inner coat is less easily ruptured, and the middle coat contains a smaller proportion of muscular tissue. In one important point veins differ structurally from arteries—namely, in being provided with valves which prevent reflux of the blood. These valves are composed of semilunar folds of the *tunica intima* strengthened by an addition of connective tissue. Each valve usually consists of two semilunar flaps attached to opposite sides of

the vessel wall, each flap having a small sinus on its cardiac side. The distension of these sinuses with blood closes the valve and prevents regurgitation. Valves are absent from the superior and inferior venæ cavæ, the portal vein and its tributaries, the hepatic, renal, uterine, and spermatic veins, and from the veins in the lower part of the rectum. They are ill-developed or absent also in the iliac and common femoral veins—a fact which has an important bearing on the production of varix in the veins of the lower extremity.

The wall of *capillaries* consists of a single layer of endothelial cells.

INJURIES OF ARTERIES

The following description of the injuries of arteries refers entirely to the larger, named trunks. The injuries of smaller, unnamed vessels are included in the consideration of contusions and wounds.

The injuries to which the larger arteries are liable are: contusion, subcutaneous rupture, laceration with an open wound, and punctured, incised, and gun-shot wounds.

Contusion.—An artery may be contused by a blow or crush, or by the oblique impact of a bullet. The bruising of the vessel wall, especially if atheroma is present, may result in the formation of a thrombus which occludes the lumen temporarily or even permanently, and in rare cases may lead to gangrene of the limb beyond.

Subcutaneous Rupture.—An artery may be ruptured subcutaneously by a blow or crush, or by a displaced fragment of bone. This injury has been produced also during attempts to reduce dislocations, especially those of old standing at the shoulder-joint. It is most liable to occur when the vessels are atheromatous. The rupture may be incomplete or complete.

Incomplete Subcutaneous Rupture.—In the majority of cases the rupture is incomplete—the inner and middle coats being torn, while the outer coat remains intact. The middle coat contracts and retracts, and the internal, because of its elasticity, curls up in the interior of the vessel, forming a valvular obstruction to the blood-flow. In most cases this results in the formation of a thrombus which occludes the vessel. In some cases the blood pressure gradually distends the injured segment of the vessel wall and leads to the formation of an aneurysm.

The pulsation in the vessels beyond the seat of rupture is almost always arrested—for a time at least—owing to the occlusion of the vessel, and the limb becomes cold and powerless. The pulsation seldom returns within five or six

weeks of the injury, if indeed it is not permanently arrested. As a rule, however, a good collateral circulation is rapidly established, the vascularity soon being restored. If the pulsation returns within a week of the injury, the presumption is that the occlusion was due to pressure from without—for example, by hæmorrhage into the sheath, or the pressure of a fragment of bone.

When an artery has been occluded as a result of contusion and thrombosis, the limb must be placed in the most favourable condition for the restoration of the circulation. The skin is disinfected and the limb wrapped in cotton wool to conserve its heat, and elevated to such an extent as to promote the venous return without at the same time unduly interfering with the inflow of blood. A careful watch must be kept on the state of nutrition of the limb, lest gangrene supervene, as this necessitates amputation at or above the level of the obstructed artery.

Complete Subcutaneous Rupture.—When the rupture is complete, all the coats of the vessel are torn and the blood escapes into the surrounding tissues. If the original injury is attended with much shock, the bleeding may not take place until the period of reaction. Rupture of the popliteal artery in association with fracture of the femur, or of the axillary or brachial artery with fracture of the humerus or dislocation of the shoulder, are the most familiar examples of this injury.

Like incomplete rupture, this lesion is accompanied by loss of pulsation and power, and by coldness of the limb beyond; a tense and excessively painful swelling rapidly appears in the region of the injury, and, where the cellular tissue is loose, may attain a considerable size. The pressure of the effused blood occludes the veins and leads to marked congestion and œdema of the limb beyond. The interference with the circulation, and the damage to the tissues of the limb, may be so great that gangrene ensues.

If no complications supervene the swelling subsides, and recovery may be complete in six or eight weeks. Even in cases of complete rupture expectant treatment has in many cases yielded satisfactory results. If the extravasation is great and the skin threatens to give way, or if the vitality of the limb is seriously endangered, it is advisable to expose the injured vessel, and, after clearing away the clots, to apply a ligature above and below the rupture. If gangrene ensues, amputation must be performed.

Open Wounds of Arteries—Laceration.—Laceration of large

arteries is a common complication of severe machinery and railway accidents. The violence being usually of a tearing, twisting, or crushing nature, such injuries are seldom associated with much hæmorrhage, as torn or crushed vessels quickly become occluded by contraction and retraction of their coats and by the formation of a clot. A whole limb even may be completely avulsed from the body with comparatively little loss of blood. The risk in such cases is secondary hæmorrhage resulting from septic infection.

The *treatment* is that applicable to all infected wounds, with, in addition, the ligation of the lacerated vessels.

Punctured wounds of blood-vessels may result from stabs, or they may be accidentally inflicted in the course of an operation.

The division of the coats of the vessel being incomplete, the natural hæmostasis that results from curling up of the intima and contraction of the media fails to take place, and bleeding goes on into the surrounding tissues, and on the surface. If the sheath of the vessel is not widely damaged, the gradually increasing tension of the extravasated blood retained within it may ultimately arrest the hæmorrhage. A clot then forms between the lips of the wound in the vessel wall and projects for a short distance into the lumen, without, however, materially interfering with the flow through the vessel. The organisation of this clot may result in the healing of the wound in the vessel wall.

In other cases the blood escapes beyond the sheath and infiltrates the surrounding tissues, and an aneurysm results. Secondary hæmorrhage may occur if the wound becomes septic.

The *treatment* consists in enlarging the external wound sufficiently to enable it to be purified, and to permit of the damaged vessel being ligated above and below the puncture. In some cases it may be possible to suture the opening in the vessel wall. When circumstances prevent these measures being taken, the bleeding may be arrested by making firm pressure over the wound with a pad, but this procedure is liable to be followed by the formation of an aneurysm.

Incised Wounds.—We here refer only to such incised wounds as partially divide the vessel wall.

Longitudinal incised wounds show little tendency to gape, and are therefore not attended with much bleeding. They usually heal rapidly, but, like punctured wounds, are liable to be followed by the formation of an aneurysm.

When, however, the incision in the vessel wall is oblique or transverse, the retraction of the muscular coat causes the opening to gape, with the result that there is profuse hæmorrhage, which, even in comparatively small arteries, may prove dangerous. When the associated wound in the soft parts is valvular, an aneurysm may develop.

When a large arterial trunk, such as the external iliac, the femoral, the common carotid, the brachial, or the popliteal, has been partly divided, for example in the course of an operation, the opening should be closed with sutures—*arteriorraphy*. The circulation being controlled by a tourniquet, or the artery itself occluded by a clamp, fine silk or catgut stitches are passed through the adventitia and media after the method of Lembert, a fine, round needle being employed. Part of the sheath of the vessel or of an adjacent fascia should be stitched over the line of suture in the vessel wall. If septic infection be excluded, there is little risk of thrombosis or secondary hæmorrhage; and even if thrombosis should develop at the point of suture, the artery is obstructed gradually, and the establishment of a collateral circulation takes place better than in the case of sudden ligation. In the case of smaller trunks, or when suture is impracticable, the artery should be tied above and below the opening, and divided between the ligatures.

Gun-shot wounds of blood-vessels are described at p. 245.

INJURIES OF VEINS

Veins are subject to the same forms of injury as arteries, and the results are in most respects alike in both, such variations as occur being dependent partly on the difference in their anatomical structure, and partly on the conditions of the circulation through them.

Subcutaneous rupture of veins occurs under the same conditions as the corresponding injury of arteries, and more particularly in association with fractures and in the reduction of dislocations. The veins most commonly ruptured are the popliteal, the axillary, the femoral, and the subclavian. On account of the smaller amount of elastic and muscular tissue in a vein, the contraction and retraction of its walls are less than in an artery, and so bleeding may continue for a much longer period. On the other hand, owing to the lower blood pressure in a vein, the outflow goes on more slowly, and the gradually increasing pressure produced by the extravasated

blood is usually sufficient to arrest the hæmorrhage before it has become serious. As an aid in diagnosing the source of the bleeding, it should be remembered that the rupture of a vein does not affect the pulsation in the limb beyond. The risks are practically the same as when an artery is ruptured, and the treatment is carried out on the same lines, but in the case of veins it is seldom necessary to operate for the purpose of applying a ligature to the injured vessel.

Wounds of veins—punctured and incised—frequently occur in the course of operations; for example, in the removal of tumours or diseased glands from the neck, the axilla, or the groin. They are also met with as a result of accidental stabs and of suicidal or homicidal injuries. The hæmorrhage from a large vein so damaged is usually profuse, but, owing to the comparatively low blood pressure, is more readily controlled by external pressure than that from an artery. When a vein is merely punctured, the bleeding may be arrested either by applying pressure with a pad of gauze, or by a lateral ligature—that is, picking up the margins of the rent in the wall and securing them with a ligature without occluding the lumen. In the large veins, such as the internal jugular, the femoral, or the axillary, it is sometimes possible to suture the opening in the wall. This does not necessarily result in thrombosis in the vessel, or in obliteration of its lumen.

When an *artery and vein are simultaneously wounded*, the features peculiar to each are present in greater or less degree. In the limbs the risk of gangrene is increased, and this is especially liable to ensue if the wound becomes infected. Punctured and gun-shot wounds implicating both artery and vein, as well as those due to modern small-bore bullets, are liable to be followed by the development of arterio-venous aneurysm.

Entrance of Air into Veins—Air Embolism.—This serious, though fortunately rare, accident is apt to occur in the course of operations in the region of the thorax, neck, or axilla, if a large vein is opened and fails to collapse on account of the rigidity of its walls, its incorporation in a dense fascia, or from traction being made upon it. If a vein is thus held open, the negative pressure during inspiration sucks air into the right side of the heart. This is accompanied by a peculiar hissing or gurgling sound, and with the next expiration some frothy blood escapes from the wound in the vessel wall. The patient instantly becomes pale, the pupils dilate,

respiration becomes laboured, and although the heart may continue to beat forcibly, the peripheral pulse is weak, and may even be imperceptible. On auscultating the heart, a churning sound may be heard. Death may result in a few minutes; or the heart may slowly regain its power and recovery take place.

These symptoms have been attributed (1) to the collection of air in the right side of the heart, so that the right ventricle has no blood on which to contract, and the pulmonary circulation is therefore stopped; (2) to the passage of air into the pulmonary vessels interfering with the circulation in the lungs, and preventing the entrance of fresh blood into the left side of the heart; and (3) to the passage of air emboli to the cerebral blood-vessels.

Prevention.—In all operations in the “dangerous area”—as the region of the root of the neck is called in this connection—great care must be taken not to notch or cut across any vein before it has been secured by forceps, and to apply ligatures securely and at once. Deep wounds in this region should be kept filled with an aseptic fluid, such as normal salt solution. Immediately a cut is recognised in a vein, a finger should be placed over the vessel on the cardiac side of the wound, and kept there until the opening is secured with forceps.

Treatment.—Little can be done after the air has actually entered the vein beyond endeavouring to keep up the heart's action by hypodermic injections of ether or strychnin, alcoholic enemata, and the application of mustard or hot cloths over the chest. The head at the same time should be lowered to prevent syncope. Attempts to withdraw the air by suction, and the employment of artificial respiration, have proved futile, and are, by some, considered dangerous.

REPAIR OF BLOOD-VESSELS, AND THE NATURAL ARREST OF HÆMORRHAGE

These processes are so intimately related to one another that it is advisable to consider them together.

(a) When the wall of an artery is *partially* torn, or punctured, it may be repaired by the clot which forms in the gap becoming organised, and subsequently converted into scar tissue. This cicatrix, however, is liable subsequently to be stretched by the blood pressure and to become the starting-point of an aneurysm.

(b) When an artery is *completely* divided, the circular fibres of the muscular coat contract, so that the lumen of the cut ends is diminished, and at the same time each segment retracts within its sheath, in virtue of the recoil of the elastic elements in its walls. The tunica intima curls up in the interior of the vessel, and the tunica adventitia collapses over the cut ends. The blood that escapes from the injured vessel fills the interstices of the tissues, and, coagulating, forms a clot which temporarily arrests the bleeding. That part of the clot which lies between the divided ends of the vessel and in the cellular tissue outside, is known as the *external clot*, while the portion which projects into the lumen of the vessel is known as the *internal clot*, and it usually extends as far as the nearest collateral branch. These processes constitute what is known as the *temporary arrest of hæmorrhage*, which, it will be observed, is effected by the contraction and retraction of the divided artery and by clotting of the blood.

The *permanent arrest* takes place by the transformation of the clot into scar tissue. The internal clot plays the most important part in the process: it becomes invaded by leucocytes and proliferating endothelial and connective-tissue cells, and new blood-vessels permeate the mass forming granulation tissue. This is ultimately replaced by cicatricial fibrous tissue, which permanently occludes the end of the vessel. Concurrently and by the same process the external clot is converted into scar tissue.

In course of time the collateral branches of the vessel above and below the level of section become enlarged and their intercommunication becomes more free, so that even when large trunks have been divided the vascular supply of the parts beyond may be completely restored. This is known as the development of the *collateral circulation*.

Repair of Veins.—The process of repair in veins is the same as that in arteries, but the thrombosed area may become canalised and the circulation through the vessel be re-established.

Conditions which influence the Natural Arrest of Hæmorrhage.—It has already been mentioned that laceration of a blood-vessel promotes the natural arrest of hæmorrhage, the twisting of the coats favouring the formation of clots. The occurrence of syncope or of profound shock also helps to stop bleeding by reducing the force of the heart's action.

On the other hand, there are various conditions which retard the natural arrest. When, for example, a vessel is only partly divided, the contraction and retraction of the muscular coat,

instead of diminishing the calibre of the artery, causes the wound in the vessel to gape; by completing the division of the vessel under these circumstances the bleeding can often be arrested. In certain situations, also, the arteries are so intimately connected with their sheaths, that when cut across they are unable to retract and contract—for example, in the scalp, in the penis, and in bones—and copious bleeding may take place from comparatively small vessels. This inability of the vessels to contract and retract occurs also in inflamed and œdematous parts and in scar tissue. Arteries divided in the substance of a muscle also sometimes bleed unduly. Any increase in the force of the heart's action, such as may result from exertion, excitement, or over-stimulation, also interferes with the natural arrest of hæmorrhage.

Lastly, in hæmophilia the deficient coagulability of the blood seriously interferes with the natural arrest of bleeding, even in small vessels.

(c) *Ligation of a Vessel in its Continuity.*—When a ligature is applied to an artery it should be pulled sufficiently tight to occlude the lumen without causing rupture of any of its coats. It often happens, however, that the compression causes rupture of the inner and middle coats, so that only the adventitia remains in the grasp of the ligature. While this weakens the wall of the vessel, it has the advantage of hastening coagulation, by bringing the blood into contact with damaged tissue. Whether the inner and middle coats are ruptured or not, blood coagulates both above and below the ligature, the proximal clot being longer and broader than that on the distal side. In small arteries these clots extend as far as the nearest collateral branch, but in the larger trunks their length varies. The permanent occlusion of those portions of the vessel occupied by clot is brought about by the formation of granulation tissue, and its replacement by cicatricial tissue, so that the occluded segment of the vessel is represented merely by a fibrous cord. In this process the coagulum only plays a passive rôle by forming a scaffolding on which the granulations are built up. The ligature surrounding the vessel, and the elements of the clot, are ultimately absorbed.

(d) In a vessel *ligated at its cut end*—as, for example, in an amputation stump—the reparative process is the same as when it is tied in its continuity. The ligature usually tears the internal and middle coats, and so pulls the adventitial coat together. The ligature and the small portion of vessel beyond it are subsequently absorbed.

HÆMORRHAGE

Various terms are employed in relation to hæmorrhage, according to its seat, its origin, the time at which it occurs, and other circumstances.

The term *external hæmorrhage* is employed when the blood escapes directly to the surface; when the bleeding takes place into the tissues or into a cavity it is spoken of as *internal*. The blood may infiltrate the connective tissue of the skin or of deeper parts, constituting an *extravasation* of blood; or it may collect in a definite space or cavity and form a *hæmatoma*.

The coughing up of blood from the lungs is known as *hæmoptysis*; vomiting of blood from the stomach, as *hæmatemesis*; the passage of black-coloured stools due to the presence of blood altered by digestion, as *melæna*; and the passage of bloody urine, as *hæmaturia*.

Hæmorrhage is known as arterial, venous, or capillary, according to the nature of the vessel from which it takes place.

In *arterial hæmorrhage* the blood is bright red in colour, and escapes from the cardiac end of the divided vessel in forcible jets synchronously with the systole of the heart. In very vascular parts—for example, the face—both ends of a divided artery bleed freely. The blood flowing from an artery may be dark in colour if the patient's respiration is impeded. The flow is sometimes continuous and not in jets, when the heart's action is weak and the blood tension low, or when the bleeding takes place into a deep wound and not directly on to the free surface.

Venous bleeding is not pulsatile, but occurs in a continuous stream, which, although both ends of the vessel may bleed, is more copious from the distal end. The blood is dark red under ordinary conditions, but may be purplish, or even black, if the patient is becoming asphyxiated. When one of the large veins in the neck is wounded, the effects of respiration produce a rise and fall in the stream which may resemble arterial pulsation. Bleeding from the cardiac end of a varicose vein may be very copious.

In *capillary hæmorrhage*, red blood escapes from numerous points on the surface of the wound in a steady ooze. This form of bleeding is often serious in those who are the subjects of hæmophilia.

In relation to the time at which it occurs, hæmorrhage is spoken of as primary, reactionary, and secondary.

Primary hæmorrhage is that which immediately follows a wound of a blood-vessel.

It is convenient to consider separately the treatment of primary hæmorrhage, as it occurs (1) in the course of a surgical operation, and (2) in an accidentally inflicted wound.

Hæmorrhage in Surgical Operations.—The management of the hæmorrhage which accompanies a surgical operation includes (a) preventive measures, and (b) the arrest of the bleeding.

Prevention of Hæmorrhage.—The most convenient and certain means of preventing hæmorrhage—say in an amputation—is by the use of some form of *tourniquet*, such as the elastic tubing of Esmarch or of Foulis, or an elastic bandage, or the screw tourniquet of Petit. Before applying any of these it is advisable to empty the limb of blood. This is best done after the manner suggested by Lister: the limb is held vertical for three or four minutes; the veins are thus emptied by gravitation, and they collapse, and as a physiological result of this the arteries reflexly contract, so that the quantity of blood entering the limb is reduced to a minimum. With the limb still elevated the tourniquet is firmly applied, a part being selected where the vessel can be pressed directly against a bone, and where there is no risk of exerting injurious pressure on important nerve-trunks. The tourniquet should be applied over several layers of gauze or lint to protect the skin, and the first turn of the tourniquet must be rapidly and tightly applied to arrest completely the arterial flow, otherwise the veins only are obstructed and the limb becomes congested. In the inferior extremity the best place to apply a tourniquet is the lower third of the thigh; in the superior extremity, in the middle of the upper arm. This “bloodless method” of operating is subject to the objection that, owing to vaso-motor paralysis of the smaller vessels caused by the pressure of the tourniquet, the oozing which takes place after its removal is often copious and persistent.

When a tourniquet cannot conveniently be applied, or when its presence interferes with the carrying out of the operation—as, for example, in amputations at the hip or shoulder—the hæmorrhage may be controlled by preliminary ligation of the main artery above the seat of operation—for instance, the external iliac or the subclavian. For such contingencies also the steel skewers used by Syme and Spence, or a special clamp or forceps, such as that suggested by Lynn Thomas, may be employed. In the case of vessels which it is undesirable to

occlude permanently, such as the carotids, the temporary application of a ligature or clamp is sometimes most useful.

Many surgeons rely for the control of hæmorrhage upon *digital compression* of the main vessel supplying the limb. The amount of blood lost immediately may be greater than when a tourniquet is used, but the small vessels bleed much less, so that the total loss of blood is probably about equal in the two methods.

In selecting a point at which to apply digital compression, it is essential that the vessel should be lying over and close to a bone which will furnish the necessary resistance. The common carotid, for example, is pressed backward and inward against the transverse process (carotid tubercle) of the sixth cervical vertebra; the temporal against the zygoma in front of the ear; and the facial against the lower jaw at the anterior edge of the masseter muscle.

In the upper extremity, the subclavian is pressed against the first rib by making pressure downwards and backwards in the hollow above the clavicle; the axillary and brachial by pressing against the shaft of the humerus.

In the lower extremity, the common femoral is controlled by pressing in a direction backward and slightly upward against the brim of the pelvis, midway between the symphysis pubis and the anterior superior iliac spine.

The abdominal aorta may be compressed against the bodies of the lumbar vertebræ opposite the umbilicus, if the spine is arched well forwards over a pillow or sand-bag, or by the method suggested by Macewen, in which the patient's spine is arched forwards by allowing the lower extremities and pelvis to hang over the end of the table, while the assistant, standing on a stool, applies his closed fist over the abdominal aorta and compresses it against the vertebral column. Momburg has successfully employed an elastic cord wound round the waist between the iliac crest and the lower border of the ribs. Means must be taken, however, to prevent the sudden rush of blood to the lower half of the body when the cord is removed interfering with the heart's action.

Arrest of Hæmorrhage.—*Ligature.*—This is the best means of securing the larger vessels. The divided vessel having been caught with forceps as near to its cut end as possible, a ligature, preferably of some absorbable material such as catgut or kangaroo tendon, is tied round it. Fine silk may be preferred on account of the greater certainty with which it can be sterilised. When there is difficulty in applying a ligature

securely, for example, in a dense tissue like the scalp or periosteum, or in a friable tissue like the thyroid gland or the mesentery, a stitch should be passed so as to surround the bleeding vessel a short distance from its end, in this way ensuring a better hold and preventing the ligature from slipping off.

If the hæmorrhage is from a partly divided vessel, this should be completely cut across to enable its walls to contract and retract, and to facilitate the application of forceps and ligatures.

Torsion.—This method is seldom employed except for comparatively small vessels, but it is applicable to even the largest arteries. In employing torsion, the end of the vessel is caught with forceps, and the terminal portion twisted round several times. The object is to tear the inner and middle coats so that they curl up inside the lumen, while the outer fibrous coat is twisted into a cord which occludes the end of the vessel.

Forci-pressure.—Bleeding from the smallest arteries and from arterioles can usually be arrested by firmly squeezing them for a few minutes with serrated or grooved artery forceps, such as those of Spencer Wells, Kocher, or Ochsner. It is usually found that on the removal of the forceps at the end of an operation no further hæmorrhage takes place from these vessels. By the use of specially strong clamps, such as the angiotribs of Doyen, large trunks may be occluded by pressure.

Cautery.—The actual cautery or Paquelin's thermo-cautery is seldom employed to arrest hæmorrhage, but is frequently useful in preventing it, as, for example, in the removal of piles, or in opening the bowel in colostomy. It is used at a dull-red heat, which sears the divided ends of the vessel and so occludes the lumen. A bright-red or a white heat cuts the vessel across without occluding it. The separation of the slough produced by the charring of the tissues is sometimes attended with secondary bleeding, and subsequent cicatricial contraction may be excessive.

Hot Water.—Profuse oozing, such, for example, as may occur from the flaps after amputation, or from the large raw surface left after excision of the knee, may sometimes be arrested by douching the part with sterilised water at a temperature of about 110° F., which acts by causing contraction of the muscular fibres of the vessel walls.

Styptics.—The local application of styptics is seldom to be recommended. In the treatment of epistaxis or bleeding from

the nose, of hæmorrhage from the socket of a tooth, and sometimes from ulcerating or granulating surfaces, however, styptics may be useful. All clots must be removed and the drug applied directly to the bleeding surface. Adrenalin and turpentine are the most useful drugs for this purpose.

Surgical Arrest of Accidental Hæmorrhage.—The most efficient means of temporarily controlling profuse hæmorrhage is by pressure applied with the finger, or with a pad of gauze, directly over the bleeding point. While this is maintained an assistant makes digital pressure, or applies a tourniquet, over the main vessel of the limb on the proximal side of the bleeding point. A useful emergency tourniquet may be improvised by folding a large handkerchief *en cravatte*, with a cork or piece of wood in the fold to act as a pad. The handkerchief is applied round the limb, with the pad over the main artery, and the ends knotted on the outer aspect of the limb. With a strong piece of wood the handkerchief is wound up like a Spanish windlass, until sufficient pressure is exerted to arrest the bleeding.

It is sometimes found on the removal of this extemporised tourniquet that the bleeding has ceased, coagula having formed in the divided vessels. As, however, such wounds are usually infected, it is seldom advisable to trust to this cessation being permanent, because if sepsis occurs in the wound it is liable later to give rise to secondary hæmorrhage. It is safer to remove from the tissues all clots that are obscuring the divided vessels, and, after purifying the wound, to ensure permanent closure of both ends of these by one or other of the means described.

When hæmorrhage is taking place from a number of small vessels, its arrest may be effected by elevation of the bleeding part, particularly if it is a limb. By this means the force of the circulation is diminished and the formation of coagula favoured. Similarly, in wounds of the hand or forearm, or of the foot or leg, bleeding may be arrested by placing a pad in the flexure and acutely flexing the limb at the elbow or knee respectively.

Reactionary or intermediary hæmorrhage is really a recurrence of primary bleeding. As the name indicates, it occurs during the period of reaction—that is, within the first few hours after an operation or injury. It may be due to the increase in the blood pressure which accompanies reaction displacing clots which have formed in the vessels, or causing vessels to bleed which did not bleed during the operation; to

the slipping of a ligature; or to the giving way of a grossly damaged portion of the vessel wall. In the scrotum, the relaxation of the dartos during the first few hours after operation occasionally leads to reactionary hæmorrhage.

As a rule, reactionary hæmorrhage takes place from small vessels as a result of the displacement of occluding clots, and in many cases the hæmorrhage stops when the bandages and soaked dressings are removed. If not, it is usually sufficient in the first instance to remove the clots and apply firm pressure, and in the case of a limb to elevate it. Should the hæmorrhage recur, the wound must be reopened, and ligatures applied to the bleeding vessels. Douching the wound with hot sterilised water (about 110° F.), and plugging it tightly with gauze, are often successful in arresting capillary oozing. When the bleeding is more copious, it is usually due to a ligature having slipped from a large vessel, and the wound must be opened up and the vessel again secured. The internal administration of morphia, by keeping the patient quiet, may prove useful in preventing the recurrence of hæmorrhage.

The term **Secondary Hæmorrhage** refers to bleeding which is due to some interference with the natural process by which an injured vessel is repaired, and it may occur at any time until the wound has completely healed. The term is also applied to the bleeding which results from erosion of a blood-vessel, for example, by an abscess burrowing into it, or by necrosis of its walls in a septic wound, or by the pressure of a drainage-tube. As secondary hæmorrhage is almost invariably the result of septic processes, it is much less frequent now than it was in pre-antiseptic days. In whatever way the infective material reaches the vessel—whether from suppuration in the wound, from the material used for ligature, or from the blood-stream—it causes softening and disintegration of the vessel wall, and of the occluding clot which is in process of organisation. The bleeding which takes place when the vessel at length gives way may at first be slight and may stop spontaneously. It soon recurs, however, and as the destructive process progresses, the recurrences become more frequent and the flow more abundant, until eventually profuse, and it may be fatal, hæmorrhage results.

The occurrence of slight hæmorrhages from a suppurating wound in the vicinity of a large blood-vessel is strongly suggestive of secondary hæmorrhage, and should always lead to steps being taken to avoid more serious bleeding, or to deal with it when it occurs. A Petit's screw tourniquet should be

loosely applied to the limb above the wound, and the nurse instructed to tighten it up in the event of bleeding taking place, and to summon the surgeon without delay. In most cases, however, it is safer to anticipate serious bleeding by operative measures. If, for example, the bleeding is from a moderate-sized vessel, it may be sufficient to wash out the wound with hot lotion, purify it with peroxide of hydrogen, and plug it tightly with iodoform or double-cyanide gauze.

When a large vessel is involved, and when the wound is badly infected and sloughing, it is safer to ligate the main vessel through a fresh incision at a selected point higher up. Should this fail to arrest the hæmorrhage, or should the procedure be likely to be followed by gangrene, it may be necessary to amputate the limb well above the infected area. Gangrene is more likely to follow ligation of the main vessels of the lower than of the upper extremity under these conditions, although we have ligated both the external iliac artery and vein for secondary hæmorrhage without gangrene ensuing. In situations in which proximal ligation is impossible—for example, in the neck, the groin, or the pelvis—firm plugging with antiseptic gauze may be the only means available.

Considerable attention has recently been devoted to the study of *hæmorrhages which depend upon infective or toxic conditions and in which no gross lesion of the vessels can be discovered*. The hæmorrhage occurs as an oozing, which may be comparatively slight and unimportant, or by its persistence may become serious. It takes place into the superficial layers of the skin, from mucous membranes, and into the substance of such organs as the pancreas. Hæmorrhages from the stomach and intestine, attended with a brown or black discoloration of the vomit and of the stools, is one of the best known examples; it is not uncommonly met with in infective conditions originating in the appendix, intestine, gall-bladder, and other organs situated within the abdomen. A similar hæmorrhage from the mucous membrane of the stomach may occur after abdominal operations—the so-called *post-operative hæmatemesis*,—but it is now believed that the infective condition and not the operation is the essential cause. The methods of treatment employed are such as may be expected to neutralise or antagonise the infection which is primarily responsible for the occurrence of the hæmorrhage.

Constitutional Effects of Hæmorrhage.—The severity of the symptoms resulting from hæmorrhage depends as much on the rapidity with which the bleeding takes place as on

the amount of blood lost. The sudden loss of a large quantity, whether from an open wound or into a serous cavity—for example, after rupture of the liver or spleen—is attended with marked pallor of the surface of the body and coldness of the skin, especially of the face, feet, and hands. The skin is moist with a cold, clammy sweat, and beads of perspiration stand out on the forehead. The pulse becomes feeble, soft, and rapid, and the patient is faint and listless, and complains of extreme thirst. The temperature is usually subnormal; and the respiration rapid, shallow, and sighing in character. Abnormal visual sensations, in the form of flashes of light or spots before the eyes; and rushing, buzzing, or ringing sounds in the ears, are often complained of. The occurrence of post-hæmorrhagic leucocytosis has been already referred to.

In extreme cases, phenomena which have been aptly described as those of “air-hunger” ensue. On account of the small quantity of blood circulating through the body, the tissues are imperfectly oxygenated, and the patient becomes extremely restless, gasping for breath, constantly throwing about his arms and baring his chest in the vain attempt to breathe more freely. Faintness and giddiness are marked features. The diminished supply of oxygen to the brain and to the muscles produces muscular twitchings, and sometimes convulsions. Finally the pupils dilate, the sphincters relax, and death ensues.

Young children stand the loss of blood badly, but they quickly recover, as the regeneration of blood takes place rapidly. In old people also, and especially when they are fat, the loss of blood is badly borne, and the ill effects last longer. Women, on the whole, stand loss of blood better than men, and in them the blood is more rapidly re-formed.

Treatment.—The treatment is practically the same as that of shock. The patient should be placed at rest in a warm, well-ventilated room, and the foot of the bed elevated. Cardiac stimulants, such as strychnin or alcohol, must be judiciously administered, over-stimulation being carefully avoided. The inhalation of oxygen has been found useful in relieving the more urgent symptoms of dyspnoea.

The blood may be emptied from the limbs into the vessels of the trunk, where it is more needed, by holding them vertically in the air for a few minutes, and then applying a firm elastic bandage over a layer of cotton wool, from the periphery towards the trunk.

Introduction of Fluids into the Circulation.—The most valuable measure for maintaining the circulation, however, is the introduction of from one to three pints of ordinary physiological salt solution (a teaspoonful of common salt to a pint of water) into a vein. The solution is sterilised by boiling, and cooled to a temperature of about 105° F. The addition of 5 or 10 minims of adrenalin solution (1 in 1000) is advantageous in raising the blood pressure.

The median basilic is the most convenient vein into which to introduce the fluid. A constricting band is applied round the upper arm to render the veins prominent, and an incision made in the long axis of the median basilic, exposing about an inch of the vessel. With an aneurysm needle two catgut ligatures are passed round the vein about an inch apart, and the lower is tied so as to occlude the vessel. A V-shaped flap, with its apex downwards, is then cut in the wall of the vein by means of scissors curved on the flat, or by transfixing the wall with a narrow-bladed knife, and a small glass or metal nozzle introduced, and retained in position by tightening up the higher ligature with a double or treble first-loop of a surgeon's knot. To this nozzle is fixed a rubber tube, from four to six feet in length, and with the calibre of a number ten catheter. Through a funnel the fluid is allowed to flow slowly into the vein, care being taken that no air enters with it. The rate of flow is regulated by raising or lowering the funnel: it should take about ten minutes to introduce a pint of solution. When the desired quantity—from one to three pints—has been introduced, the nozzle is withdrawn, the ligatures holding it being at the same moment tightened and secured. The vein is then divided between the ligatures, the skin sutured, and a dressing applied.

When the intra-venous method is not available, one or two pints of saline solution with adrenalin should be slowly introduced into the rectum, by means of a long rubber tube and a filler. Satisfactory, although less rapidly obtained results follow the introduction of saline solution into the cellular tissue—for example, under the mamma, into the axilla, or under the skin of the back.

If the patient can retain fluids taken by the mouth—such as hot coffee, barley water, or soda water—these should be freely given, unless the injury necessitates operative treatment under a general anæsthetic.

The introduction of blood obtained from a healthy person is sometimes employed in the treatment of shock and various forms

of anæmia. Crile believes that transfusion is the best treatment for combined shock and hæmorrhage. The blood is made to flow directly from the radial artery of the donor into the median basilic or other vein of the receiver.

HÆMOPHILIA

The term hæmophilia is applied to an inherited disease which renders the patient liable to serious hæmorrhage from even the most trivial injuries; and the subjects of it are popularly known as "bleeders."

The essential cause of the disease and its true nature are as yet unknown. There is no proof of any structural defect in the blood-vessels, and beyond the fact that there is a diminution in the number of blood-plates, it has not been demonstrated that there is any alteration in the composition of the blood.

The affection is in a marked degree hereditary, all the branches of an affected family being liable to suffer. Its mode of transmission to individuals, moreover, is characteristic: the male members of the stock alone suffer from the affection in its typical form, while the tendency is transmitted through the female line. Thus the daughters of a father who is a bleeder, whilst they do not themselves suffer from the disease, transmit the tendency to their male offspring. The sons, on the other hand, neither suffer themselves nor transmit the disease to their children (Fig. 63). The female members of hæmophilic stock are often very prolific, and there is usually a predominance of daughters in their families.

The disease is met with in boys who are otherwise healthy, and usually manifests itself during the first few years of life. In rare instances profuse hæmorrhage takes place when the umbilical cord separates. As a rule the first evidence is the occurrence of long-continued and uncontrollable bleeding from a comparatively slight injury, such as the scratch of a pin, the extraction of a tooth, or after the operation of circumcision. The blood oozes slowly from the capillaries; at first it appears normal, but after flowing for some days, or it may be weeks, it becomes pale, thin, and watery, and shows less and less tendency to coagulate.

Female members of hæmophilic families sometimes show a tendency to excessive hæmorrhage, but they seldom manifest the characteristic features met with in the male members.

Sometimes the hæmorrhage takes place apparently spontane-

ously from a mucous surface, such as the gums, the nasal or the intestinal mucous membrane. In other cases the bleeding occurs into the cellular tissue under the skin or mucous membrane, producing large areas of ecchymosis and discoloration. One of the commonest manifestations of the disease is the occurrence of hæmorrhage into the synovial cavities of the large joints, especially the knee, elbow, or hip. The patient suffers repeatedly from such hæmorrhages, the determining injury being often so slight as to have passed unobserved.

There is evidence that the tendency to bleed is greater at certain times than at others—in some cases showing almost a cyclical character—although nothing is known as to the cause of the variation.

After a severe hæmorrhage into the cellular tissue or into a joint, the patient becomes pale and anæmic, the temperature may rise to 102° or 103° F., the pulse become small and rapid,



FIG. 64.—Extensive subcutaneous Effusion in case of Hæmophilia. The condition simulated Acute Osteomyelitis of Tibia.

and hæmic murmurs are sometimes developed over the heart and large arteries. The swelling is tense, fluctuating, and hot, and there is considerable pain and tenderness.

In exceptional cases, blisters form over the seat of the effusion, or the skin may even slough, and the clinical features may therefore come to simulate closely those of an acute suppurative condition.

The acute symptoms gradually subside, and the effused blood is slowly absorbed, the discoloration of the skin passing through the same series of changes as occur after an ordinary bruise. Prolonged hæmorrhage is usually associated with a subnormal temperature. The patients seldom manifest the symptoms of the bloodless state, and the blood is rapidly regenerated.

The *diagnosis* is easy if the patient or his friends are aware of the family tendency to hæmorrhage and inform the surgeon of it, but they are often sensitive and reticent

regarding the fact, and it may only be elicited after close investigation. From the history it is usually easy to exclude scurvy and purpura. Repeated hæmorrhages into a joint may result in appearances which closely simulate those of tuberculous disease. Recent hæmorrhages into the cellular tissue often present clinical features closely resembling those of acute cellulitis or osteomyelitis (Fig. 64). A careful examination, however, may reveal ecchymoses on other parts of the body which give a clue to the nature of the condition, and may prevent the disastrous consequences that would follow incision of the swelling.

The *prognosis* is, on the whole, unfavourable, as these patients usually succumb sooner or later to hæmorrhage, although they often survive several severe attacks. After middle life the tendency to bleed appears to diminish.

Treatment.—As a rule the ordinary means of arresting hæmorrhage are of little avail. From among the numerous means suggested, the following may be mentioned. The application to the bleeding point of gauze soaked in a 1 in 1000 solution of adrenalin; prolonged inhalation of oxygen; freezing the part with a spray of ethyl-chloride; one or more subcutaneous injections of gelatin—five ounces of a 2½ per cent. solution of white gelatin in normal salt solution being injected at a temperature of about 100° F. The application of a pad of gauze soaked in the blood of a normal person sometimes arrests the bleeding.

To prevent bleeding in hæmophilics, intra-venous or subcutaneous injections of fresh blood serum, taken from the human subject, the dog, the horse, or the rabbit, have proved useful (Weil).

The chloride and lactate of calcium, and extract of thymus gland have been employed to increase the coagulability of the blood. The patient should drink large quantities of milk, which also increases the coagulability of the blood.

THROMBOSIS AND EMBOLISM

The processes known as thrombosis and embolism are so intimately associated with the diseases of blood-vessels that it is convenient to define these terms in the first instance.

Thrombosis.—The term *thrombus* is applied to a clot of blood formed in the interior of the heart or of a blood-vessel, and the process by which such a clot forms is known as *thrombosis*. The essential cause of thrombosis is as yet not

thoroughly understood. It would appear, however, that slowing or stagnation of the blood-stream, and interference with the integrity of the lining membrane of the vessel wall, are the most important factors determining the formation of the clot. When the thrombus is formed slowly, it is of a greyish-white colour, and, being deposited in successive layers, has a distinctly laminated appearance on section. This is known as a *white thrombus* or laminated clot, and is often met with in the sac of an aneurysm (Fig. 71). When rapidly formed in a vessel in which the blood is almost stagnant—as, for example, in a pouched varicose vein—the blood coagulates *en masse*, and the clot consists of all the elements of the blood, constituting a *red thrombus* (Fig. 66). Sometimes the thrombus is mixed—a red thrombus being deposited on a white one, it may be in alternate layers.

When aseptic, a thrombus usually undergoes organisation; or a portion of it may become detached and be carried off in the blood-stream as an embolus, or it may degenerate and undergo calcification.

Occasionally a small thrombus situated behind a valve in a varicose vein or in the terminal end of a dilated vein—for example, in a pile—undergoes calcification, and is then spoken of as a *phlebolith*.

When infected with pyogenic bacteria, the thrombus becomes converted into pus and a localised abscess may form; or portions of the thrombus may be carried as septic emboli in the circulation to distant parts, where they give rise to secondary foci of suppuration—pyæmic abscesses.

Embolism.—The term *embolus* is applied to any body carried along in the arterial circulation and ultimately impacted in one of the arteries. This occurrence is known as *embolism*. The commonest forms of embolus are portions of thrombi or of fibrinous formations on the valves of the heart, the latter being usually infected with micro-organisms.

Embolism plays an important part in determining one form of gangrene, as has already been described. Septic emboli are the direct cause of the secondary abscesses that occur in pyæmia; and they are sometimes responsible for the formation of aneurysm.

Portions of malignant tumours also may form emboli, and their impaction in the vessels may lead to the development of secondary growths in distant parts of the body.

Fat and air embolism have already been referred to.

ARTERITIS

Arteritis due to Pyogenic Organisms.—In arteritis due to pyogenic organisms, the infection may take place by direct spread from a focus of suppuration in the vicinity of the artery, from an imperfectly sterilised ligature applied to the vessel, or from the blood-stream in the form of a septic embolus. The vessel wall undergoes inflammatory softening, and the blood in the lumen may coagulate. The giving way of the wall of a vessel so affected is the chief cause of secondary hæmorrhage. Sometimes the vessel ruptures into an abscess cavity, and dangerous bleeding may occur when the abscess bursts or is opened.

When the inflammatory reaction stops short of suppuration, the softening of the vessel wall may lead to aneurysmal dilatation. This occurs in embolic arteritis, and is frequently associated with disease of the valves of the heart. It is not uncommon in children, and explains many of the aneurysms met with in young subjects.

Syphilitic Arteritis.—The inflammation of arteries associated with syphilis results in marked thickening of the tunica intima, whereby the lumen of the vessel becomes narrowed, or even obliterated—*endarteritis obliterans*. The middle coat usually escapes, but the tunica adventitia is generally thickened. These changes are best seen in the smaller vessels of the brain and of the abdominal viscera, and they cause serious interference with the nutrition of the parts supplied by the affected arteries. In large trunks, by diminishing the elasticity of the vessel wall, they are liable to lead to the formation of an aneurysm.

Changes in the arterial walls closely resembling those of syphilitic arteritis are sometimes met with in *tuberculous* lesions.

Atheroma.—This name is applied to certain changes which occur in the deeper layers of the tunica intima, whereby an increased development of young connective tissue takes place. In course of time this new tissue undergoes degeneration, at first usually of a fatty nature, but progressing in the direction of calcification, and this is usually followed by the deposit of lime salts in the young connective tissue, and the formation of calcareous plates or rings over a considerable area of the vessel wall. The endothelium over these plates often disappears, leaving them exposed to the blood-stream, whereby they favour the occurrence of thrombosis.

Changes of a similar kind sometimes occur in the middle coat, the lime salts being deposited among the muscle fibres in concentric rings.

The primary cause of atheroma is not definitely known, but its almost constant occurrence in the aged, to a greater or less degree, suggests that it is of the nature of a senile degeneration. It is favoured by anything which throws excessive strain on the vessel walls, such as heavy muscular work; by chronic alcoholism and syphilis; or by such general diseases as tend to raise the blood pressure—for example, chronic Bright's disease or gout.

It occurs with greater frequency and with greater severity in men than in women. The large arterial trunks are chiefly affected, and the changes are most marked at the arch of the aorta, opposite the flexures of joints, at the mouths of large branches, and at parts where the vessel lies in contact with bone.

The presence of these calcareous plates in the wall of an artery diminishes its elasticity and favours aneurysmal dilatation. Such a vessel also is liable to be ruptured by external violence and so give rise to traumatic aneurysm. In the smaller vessels atheroma may lead to diminution or even to occlusion of the lumen—a condition which in the lower limb predisposes to gangrene. Thrombosis is liable to occur when the plates are exposed in the lumen of the vessel by destruction of the endothelium, and this predisposes to embolism. Atheroma also interferes with the natural arrest of hæmorrhage, and by rendering the vessels brittle, makes it difficult to secure them by ligature. In advanced cases, the accessible arteries—such as the radial, the temporal, or the femoral—may be felt as firm, tortuous cords, which are sometimes so hard that they have been aptly compared to “pipe-stems.” The pulse is smaller and less compressible than normal, and the vessel moves bodily with each pulsation.

Thrombosis in Veins and Thrombo-Phlebitis.—Thrombosis is more common in veins than in arteries, probably because the conditions which favour the formation of thrombi—slowing of the blood-stream and irritation of the endothelium of the vessel wall—are, owing to the conditions of the venous circulation, more readily induced in veins.

Venous thrombosis may occur from purely mechanical causes—as, for example, when the wall of a vein is incised, or the vessel included in a ligature, or when it is bruised or crushed by a fragment of a broken bone or by a bandage too

tightly applied. Under these conditions thrombosis is essentially a reparative process, and has already been considered in relation to the repair of blood-vessels.

In other cases thrombosis is associated with certain constitutional diseases—for example, gout and rheumatism; the endothelium of the veins undergoing changes—possibly the result of irritation by abnormal constituents in the blood—which favour the formation of thrombi.

Under these various conditions the formation of a thrombus is not necessarily associated with the action of bacteria, although in any of them this additional factor may be present.

The most common cause of venous thrombosis, however, is inflammation of the wall of the vein—phlebitis.

Phlebitis.—Various forms of phlebitis are met with, but for practical purposes they may be divided into two groups—one in which there is a tendency to the formation of a thrombus; the other in which the infective element predominates.

In surgical patients, the *thrombotic form* is almost invariably met with in the lower extremity, and usually occurs in those who are debilitated and anæmic, and who are confined to bed for prolonged periods—for example, during the treatment of fractures of the leg or pelvis, or after such operations as herniotomy, prostatectomy, or those performed for appendicitis.

Clinical Features.—The most typical example of this form of phlebitis is that so frequently met with in the internal saphena vein, especially when it is varicose. The onset of the attack is usually indicated by a sudden pain in the lower limb—sometimes below, sometimes above the knee. This initial pain may be associated with shivering or even with a rigor, and the temperature usually rises one or two degrees. There is swelling and tenderness along the line of the affected vein, and the skin over it is a dull-red or purple colour. The swollen vein may be felt as a firm cord, with bead-like enlargements in the position of the valves. The patient experiences a feeling of stiffness and tightness throughout the limb. There is often œdema of the leg and foot, especially when the limb is in the dependent position. The acute symptoms pass off in a few days, but the swelling and tenderness of the vein and the œdema of the limb may last for many weeks.

When the deep veins—iliac, femoral, popliteal—are involved, there is usually great swelling of the whole limb, which is of a firm, almost “wooden” consistence, and of a pale-white colour; the œdema may be so great, that it is impossible to feel the

affected vein until the subsidence of the swelling. This is most often seen in puerperal women, and is known as *phlegmasia alba dolens*.

Treatment.—The patient must be placed at absolute rest, with the foot of the bed raised on blocks ten or twelve inches high, and the limb immobilised by sand-bags or splints. It is necessary to avoid handling the parts, lest the clot be displaced and embolism occur. To avoid frequent movement of the limb, the necessary dressings should be kept in position by means of a many-tailed rather than a roller bandage.

To relieve the pain, warm fomentations, or lead and opium lotion, should be applied. Later, glycerin and belladonna, or ichthyol glycerin, may be substituted.

When, at the end of three weeks, the danger of embolism is past, douching and gentle massage may be employed to disperse the œdema; and when the patient gets up he should wear a supporting elastic bandage.

The *infective* form usually begins as a peri-phlebitis arising in connection with some focus of infection in the adjacent tissues. The elements of the vessel wall are destroyed by suppuration, and the thrombus in its lumen becomes infected with pyogenic bacteria and undergoes softening. In some cases the organisms reach the thrombus directly from the blood-stream, in others from infected ligatures or instruments—as, for example, in operations for varicose veins or hæmorrhoids.

Portions of the softened thrombus are liable to become detached and to enter the circulating blood, in which they are carried as septic emboli. These may lodge in distant parts, and give rise to secondary foci or suppuration—pyæmic abscesses (p. 73).

Clinical Features.—Infective phlebitis is most frequently met with in the lateral sinus as a sequel to chronic suppuration in the mastoid antrum and middle ear. It also occurs in relation to the peripheral veins, but in these it can seldom be recognised as a separate entity, being merged in the general septic process from which it takes origin. Its occurrence may be inferred, if in the course of a suppurative lesion there is a sudden rise of temperature, with pain, redness and swelling along the line of a venous trunk, and a rapidly developed œdema of the limb, with pitting of the skin on pressure. In rare cases a localised abscess forms in the vein and points towards the surface.

Treatment.—In the case of the peripheral veins attention

must be directed towards the condition with which the phlebitis is associated. In some cases—for example, in septic compound fractures—the occurrence of suppurative phlebitis may necessitate amputation of the limb. Ligation of the vein on the cardiac side of the thrombus with a view to preventing embolism is seldom feasible in the peripheral veins, although, as will be pointed out later, the jugular vein is ligated with this object in cases of phlebitis of the lateral sinus.

VARIX—VARICOSE VEINS

The term varix is applied to a condition in which veins are so altered in structure that they remain permanently dilated, and are at the same time lengthened and tortuous. Two types are met with: one in which dilatation of a large superficial vein and its tributaries is the most obvious feature; the other, in which bunches of distended and tortuous vessels develop at one or more points in the course of a vein, a condition to which Virchow applied the term *angioma racemosum venosum*. The two types may occur in combination.

Any vein in the body may become varicose, but the condition is extremely rare except in the veins of the lower extremity, in the veins of the spermatic cord (varicocele), and in the veins of the anal canal (hæmorrhoids).

Varicocele and hæmorrhoids will be described elsewhere. We are here concerned with varix as it occurs in the veins of the lower extremity.

Etiology.—Considerable difference of opinion exists as to the essential cause of varix. The weight of evidence is in favour of the view that, when dilatation is the predominant element, it results from a congenital deficiency in the number, size, and strength of the valves of the affected veins, and in an inherent weakness in the vessel walls. The *angioma racemosum venosum* is probably also due to a congenital alteration in the structure of the vessels, and is allied to certain of the angiomata. The view that varix is congenital in origin, as was first suggested by Virchow, is supported by the fact that in a large proportion of cases the condition is hereditary; not only may several members of the same family in succeeding generations suffer from varix, but it is often found that the same vein, or segment of a vein, is involved in all of them. The frequent occurrence of varix in youth is also an indication of its congenital origin.

In the majority of cases it is only when some exciting factor

comes into operation that the clinical phenomena associated with varix appear. The most common exciting cause of varicosity is increased pressure within the veins, and this may be produced in a variety of ways. In certain diseases of the heart, lungs, and liver, for example, the venous pressure may be so raised as to cause a localised dilatation of such veins as are congenitally weak. The direct pressure of a tumour or of the gravid uterus on the large venous trunks in the pelvis, may so obstruct the flow as to distend the veins of the lower extremity. It is a common experience that in women the signs of varix date from an antecedent pregnancy. The importance of the wearing of tight garters as a factor in the production of varicose veins has been much exaggerated, although it must be admitted that this practice is calculated to aggravate the condition when it is once established. It has been proved experimentally that the backward pressure in the veins may be greatly increased by straining, a fact which helps to explain the frequency with which varicosity occurs in the lower limbs of athletes and of those whose occupation involves repeated and violent muscular efforts. There is reason to believe, moreover, that a sudden strain may, by rupturing the valves and so rendering them incompetent, induce varicosity independently of any congenital defect. Prolonged standing or walking, by allowing gravity to act on the column of blood in the veins of the lower limbs, is also an important determining factor in the production of varix.

Thrombosis of the deep veins—in the leg, for example—may induce marked dilatation of the superficial veins, by throwing an increased amount of work upon them. This is to be looked upon rather as a compensatory hypertrophy of the superficial vessels than as a true varix.

Morbid Anatomy.—In the lower extremity the varicosity most commonly affects the vessels of the internal saphena system; less frequently those of the external saphena system. Sometimes both systems are involved, and abnormally large communicating branches may develop between the two.

The essential lesion is the absence or deficiency of valves, so that they are incompetent and fail to support the column of blood which bears back upon them. Normally the valves in the femoral and iliac veins and in the inferior vena cava are imperfectly developed, so that in the erect posture the internal saphena receives a large share of the backward pressure of the column of venous blood.

The whole length of the vein may be affected, but as a rule

the disease is confined to one or more segments, which are not only dilated, but are also increased in length, so that they become more or less convoluted. The adjacent loops of the convoluted vein are often bound together by fibrous tissue. All the coats are thickened, chiefly by an increased development of connective tissue, and in some cases changes similar to those of atheroma occur. The walls of varicose veins are often exceedingly brittle. In some cases the thickening is uniform, and in others it is irregular, so that here and there thin-walled sacs or pouches project from the side of the vein (Fig. 65). These pouches vary in size from a bean to a hen's egg, the larger forms being called *venous cysts*, and being most commonly met with in the region of the saphenous opening and of the opening in the popliteal fascia. Such pouches, being exposed to injury, are frequently the seat of thrombosis (Fig. 66).



Clinical Features. — Varix is most frequently seen in patients between puberty and the age of thirty, and the sexes appear to suffer about equally.

The amount of discomfort caused by varicose veins bears no direct proportion to the extent of the varicosity. It depends

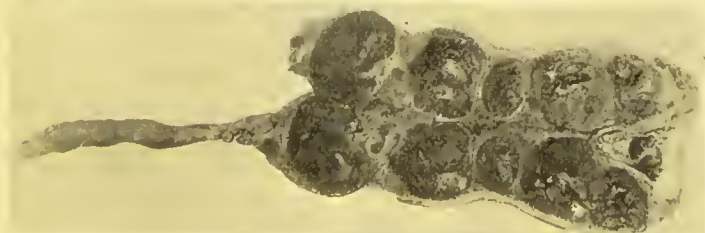


FIG. 65.—Resected portion of Varicose Vein, showing Tortuosity and unequal Dilatation.

FIG. 66.—Thrombosis in Tortuous and Pouched Internal Saphenous Vein, in longitudinal section.

rather upon the degree of pressure in the veins, as is shown by the fact that it is relieved by elevation of the limb. When the whole length of the main trunk of the internal saphenous vein is

implicated, the pressure in the vein is high and the patient suffers a good deal of pain and discomfort. When, on the contrary, the upper part of the saphena and its valves are intact, and only the more distal veins are involved, the pressure is not so high and there is comparatively little suffering. The usual complaint is of a sense of weight and fulness in the

limb after prolonged standing or walking, sometimes accompanied by actual pain, from which relief is at once obtained by raising the limb. Cramp-like pains in the muscles are often associated with varix of the deep veins.

The dilated and tortuous vein can be readily seen and felt. In advanced cases, bead-like swellings are sometimes to be detected over the position of the valves, and, on running the fingers along the course of the vessel, a firm ridge, due to periphlebitis, may be detected on each side of the vein. When the limb is œdematous, the outline of the veins is often obscured, but they can be identified on palpation as



FIG. 67.—Extensive Varix of Internal Saphena System on Left Leg, and slight Varix of External Saphena System on Right Leg.

gutter-like tracks. When large veins are implicated, a distinct impulse on coughing may sometimes be seen to pass down as far as the knee; and if the vessel is sharply percussed a fluid wave may be detected passing both up and down the vein.

If the patient is placed on a couch and the limb elevated, the veins are emptied, and if pressure is then made over the region

of the saphenous opening and the patient allowed to stand up, so long as the internal saphena system alone is involved, the veins fill again very slowly from below. If the external saphena system also is involved, and if communicating branches are dilated, the veins fill up from below more rapidly. When the pressure over the saphenous opening is removed, the blood rapidly rushes into the varicose vessels from above; this is known as Trendelenburg's test.

The most marked dilatation usually occurs on the inner side of the limb, between the middle of the thigh and the middle of the calf, the arrangement of the veins showing great variety (Fig. 67).

There are usually one or more bunches of enlarged and tortuous veins in the region of the knee, and sometimes at the ankle. Frequently a large branch establishes a communication between the systems of the internal and external saphenous veins in the region of the popliteal space, or across the front of the upper part of the tibia. The superficial position of this last branch and its proximity to the bone render it very liable to injury.

The small veins of the skin often show as fine blue streaks arranged in a stellate or arborescent manner, especially in women who have borne children.

Complications.—When the varicosity is of long standing, the skin in the lower part of the leg sometimes assumes a mahogany-brown or bluish hue, as a result of the *deposit of pigment* in the tissues, and this is frequently a precursor of ulceration.

Chronic eczema is often met with in the lower part of the leg in association with varix, and is due to interference with the nutrition of the skin. The incompetence of the valves allows the pressure in the varicose veins to equal that in the arterioles, so that the capillary circulation is impeded. From the same cause the blood in the deep veins is enabled to enter the superficial veins, where the backward pressure is so great that the blood flows down again, and so a vicious circle is established. The blood therefore loses more and more of its oxygen, and so fails to nourish the tissues.

The *ulcers* associated with varicose veins have already been described.

Hæmorrhage may take place from a varicose vein as a result of a wound or of ulceration of its wall. Increased intra-venous pressure produced by severe muscular strain may determine rupture of a vein exposed in the floor of an ulcer. If the limb is dependent, the incompetency of the valves permits of

very rapid and copious bleeding, which may prove fatal, particularly if the patient is intoxicated when the rupture takes place and no means are taken to arrest the hæmorrhage. The bleeding may at once be arrested by elevating the limb, or by applying pressure directly over the bleeding point.

Phlebitis and thrombosis are common sequelæ of varix, and may prove dangerous, either by spreading into the large venous trunks or by giving rise to emboli. The larger the varix the greater is the tendency for a thrombus to spread upwards and to involve the deep veins. Thrombi usually originate in venous cysts or pouches, and at acute bends on the vessel, especially when these are situated in the vicinity of the knee, and are subjected to repeated injuries—for example, in riding. Phleboliths sometimes form in such pouches, and may be recognised in a radiogram. In a certain proportion of cases, especially in elderly people, the occurrence of thrombosis leads to cure of the condition by the thrombus becoming organised and obliterating a segment of the vein.

Treatment.—At best the treatment of varicose veins is only palliative, as it is obviously impossible to restore to the vessels their normal structure. The patient must avoid wearing anything, such as a garter, which constricts the limb, and any obvious cause of direct pressure on the pelvic veins, such as a tumour, persistent constipation, or an ill-fitting truss, should be removed. Cardiac, renal, or pulmonary causes of venous congestion must also be treated, and the functions of the liver regulated. Severe forms of muscular exertion and prolonged standing or walking are to be avoided, and the patient may with benefit rest the limb in an elevated position for a few hours each day. To support the distended vessels, a closely woven silk or worsted stocking, or a light and porous form of elastic bandage, applied as a puttee, should be worn. These appliances should be put on before the patient leaves his bed in the morning, and should only be removed after he lies down again at night. In this way the vessels are never allowed to become dilated. Elastic stockings, and bandages made entirely of india-rubber, are to be avoided. In early and mild cases these measures are usually sufficient to relieve the patient's discomfort.

Operative Treatment.—In aggravated cases, when the patient is suffering pain, when his occupation is interfered with by repeated attacks of phlebitis, or when there are large pouches on the veins, operative treatment is called for. The younger the patient the clearer is the indication to operate. The presence of an ulcer does not contra-indicate operation; the

ulcer should be excised, and the raw surface covered with Thiersch grafts, before dealing with the veins. It may be necessary to operate to enable a patient to enter any of the public services, even although the condition gives him no trouble.

The *operation of Trendelenburg* is especially appropriate to cases in which the trunk of the internal saphena vein in the thigh is alone involved. It consists in exposing three or four inches of the vein in its upper part, applying a ligature at the upper and lower ends of the exposed portion, and, after tying all tributary branches, resecting this portion of the vein.

The procedure of C. H. Mayo is adapted to cases in which it is desirable to remove longer segments of the veins. It consists in the employment of special instruments known as "ring-enucleators" or "vein-strippers," by means of which long portions of the vein are removed through comparatively small incisions.

An alternative procedure consists in avulsing segments of the vein by means of Babcock's stylet, which consists of a flexible steel rod, 30 inches in length, with acorn-shaped terminals. The instrument is passed along the lumen of the segment to be dealt with, and a ligature applied around the vein above the bulbous end of the stylet enables nearly the whole length of the internal saphena vein to be dragged out in one piece. These methods are not suitable when the veins are brittle, when there are pouches or calcareous deposits in their walls, or where there has been much periphlebitis binding the coils together.

Mitchell of Belfast advises exposing the varices at numerous points by half-inch incisions, and, after clamping the vein between two pairs of forceps, cutting it across and twisting out the segments of the vein between adjacent incisions. The edges of the incisions are brought into apposition by pressure with pads of gauze; and the limb is firmly bandaged from below upwards, and kept in an elevated position. We have employed this method with satisfactory results.

The treatment of the complications of varix has already been considered.

ANGIOMATA¹

Tumours of blood-vessels may be divided, according to the nature of the vessels of which they are composed, into the capillary, the venous, and the arterial angioma.

¹ In the description of angioma we have followed the teaching of the late John Duncan.

CAPILLARY ANGIOMA

The most common form of capillary angioma is the *nævus* or congenital telangiectasis.

Nævus.—A *nævus* is a collection of dilated capillaries, the afferent arterioles and the efferent venules of which often share in the dilatation. As is the case with other tumours, little is known regarding the *etiology* of *nævi* beyond the fact that they are of congenital origin. They often escape notice until the child is some days old, but attention is usually drawn to them within a fortnight of birth. For practical purposes the most useful classification of *nævi* is into the cutaneous, the subcutaneous, and the mixed forms.

The cutaneous nævus, “mother’s mark,” or “port-wine stain,” consists of an aggregation of dilated capillaries in the substance of the skin. On stretching the skin the vessels may be seen to form a fine network, or to run in leashes parallel to one another. A dilated arteriole or a vein winding about among the capillaries may sometimes be detected. These *nævi* may occur on any part of the body, but they are most frequently met with on the face. They may be multiple, and vary greatly in size, some being no bigger than a pin-head, while others may cover large areas of the body. In colour they may present every tint from purple to brilliant red; in the majority there is a considerable dash of blue, especially in cold weather.

Unlike the other forms of *nævi*, the cutaneous variety shows little tendency to disappear, and it is especially persistent when associated with hypertrophy of the skin—*nævoid mole*.

As the *nævoid* tissue cannot be removed without producing a scar, which in most cases is even more disfiguring than the *nævus*, *treatment* is very unsatisfactory. In very small *nævi*, igni-puncture and escharotics, such as nitric acid, have been successfully employed. Radium and CO_2 snow have also yielded satisfactory results in some cases.

The purely *subcutaneous* *nævus* is comparatively rare. It sometimes constitutes a well-defined, localised tumour, which may possess a distinct capsule, especially when it has ceased to grow or is retrogressing. On section, it presents the appearance of a finely reticulated sponge.

Although it may be noticed at or within a few days of birth, a subcutaneous *nævus* is often overlooked, especially when on a covered part of the body, and may not be discovered till the patient is some years old. It forms a rounded, lobulated swelling, seldom of large size, and the skin over it is normal in

appearance, or may exhibit a bluish tinge, especially in cold weather. The tumour may be diminished by pressing the blood out of it, but slowly fills again when the pressure is relaxed, and it may swell up when the child struggles or cries, features which serve to distinguish it clinically from such subcutaneous swellings as fatty, cystic, and sarcomatous tumours. From a cold abscess it is diagnosed by the history and progress of the swelling and by the absence of fluctuation. When situated over one of the hernial openings, a subcutaneous nævus may closely simu-



FIG. 68.—Mixed Nævus of Nose, which was subsequently cured by Electrolysis.

late a hernia; and when it occurs in the middle line of the face, head, or back, it may be mistaken for such other congenital conditions as meningocele or spina-bifida. When other means fail, the use of an exploring needle may clear up the diagnosis.

Mixed Nævus.—As its name indicates, the mixed nævus partakes of the characters of the other two varieties; that is, it is a subcutaneous nævus which involves the skin.

It is frequently met with on the face and head, but may occur on any part of the body. It sometimes affects parts covered by mucous membrane, such as the cheek, tongue, and

soft palate. The swelling is rounded or lobulated, and projects beyond the level of its surroundings. Sometimes the skin is invaded by the nævoid tissue over the whole extent of the tumour, sometimes only over a limited area. Frequently the margin only is of a bright-red colour, while the skin over the centre resembles a cicatrix. Like a subcutaneous nævus, the swelling can be reduced by steady pressure, and increases in size and becomes tense when the child cries.

Prognosis.—The rate of growth of the subcutaneous and mixed forms of nævi varies greatly. They sometimes increase

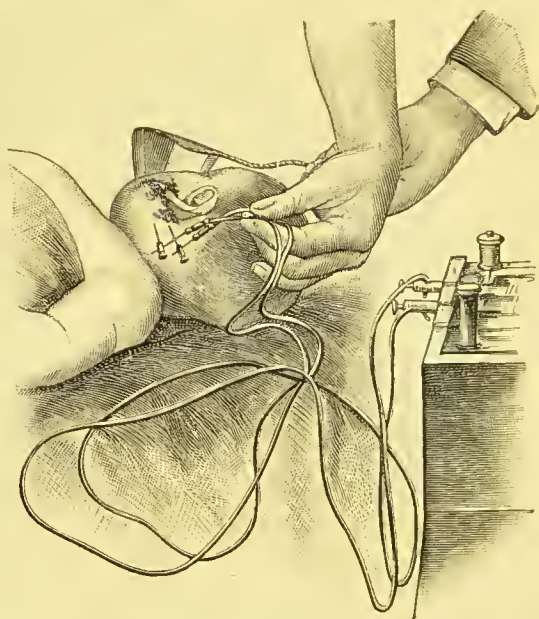


FIG. 69.—Electrolysis of Nævus under Chloroform Anæsthesia.

very rapidly, especially during the first few months of life; after this they usually grow at the same rate as the child, or more slowly. There is a decided tendency to spontaneous disappearance of these varieties, fully 50 per cent. undergoing natural cure by a process of obliteration, similar to the obliteration of vessels in cicatricial tissue. This usually begins about the period of the first dentition, sometimes at the second dentition, and sometimes at puberty. On the other hand, an increased activity of growth may be shown at these periods. The onset of natural cure is recognised by the tumour becoming firmer and less compressible, and, in the mixed variety, by the

colour becoming less bright. Injury, inflammation, or ulceration of the overlying skin may initiate the curative process.

Towards adult life the spaces in a subcutaneous nævus may become greatly enlarged, leading to the formation of a cavernous angioma.

Treatment.—In view of the frequency with which subcutaneous and mixed nævi disappear spontaneously, interference is only called for when the growth of the tumour is out of proportion to that of the child, or when, from its situation—for example, in the vicinity of the eye—any marked increase in its size would render it less amenable to treatment.

The methods of treatment most generally applicable are igni-puncture, electrolysis, and excision, and more recently the use of radium and carbon dioxide snow.

For large nævi situated on an exposed part of the body, where it is desirable to avoid a scar, either igni-puncture or electrolysis is to be preferred. Excision is better when the nævus is on a part covered by the clothes. The application of radium and of carbon dioxide snow has largely replaced these older methods.

Igni-puncture consists in making a number of punctures at different parts of the nævus with a fine-pointed Paquelin's thermo-cautery, with the object of starting at each point a process of cicatrisation which extends throughout the nævoid tissue and so obliterates the vessels.

Electrolysis acts by decomposing the blood and tissues into their constituent elements—oxygen and acids appearing at the positive, hydrogen and bases at the negative electrode. These substances and gases being given off in a nascent condition, at once enter into new combinations with anything in the vicinity with which they have a chemical affinity. In the nævus the practical result of this reaction is that at the positive pole nitric acid, and at the negative pole caustic potash, both in a state of minute subdivision, make their appearance. The effect on the tissues around the positive pole, therefore, is equivalent to that of an acid cauterisation, and on those round the negative pole, to an alkaline cauterisation.

As the process is painful, a general anæsthetic is necessary. The current used should be from 20 to 80 milliampères, gradually increasing from zero, without shock; three to six large Bunsen cells give a sufficient current, and no galvanometer is required. Steel needles, insulated with vulcanite to within an eighth of an inch of their points, are the best. Both poles are introduced into the nævus, the positive being kept fixed at one

spot, while the negative is moved about inside the tumour, so as to produce a number of different tracks of cauterisation. On no account must either pole be allowed to come in contact with the skin, lest a slough be formed. The duration of the sitting is determined by the effect produced, as indicated by the hardening of the tumour, the average duration being from fifteen to twenty minutes. If pallor of the skin appears, it indicates that the needles are too near the surface, or that the blood-supply to the integument is being cut off, and is an indication to stop. To cauterise the track and so prevent bleeding, the needles should be slowly withdrawn while the current is flowing. When the skin is reached the current is turned off. The punctures are covered with collodion. Six or eight weeks should be allowed to elapse before repeating the procedure. From two to eight or ten sittings may be necessary, according to the size and character of the nævus.

Excision is to be preferred for nævi of moderate size situated on covered parts of the body, where a scar is of no importance. When only a small proportion of the nævus is cutaneous, the invaded piece of skin may be removed with the tumour. Its chief advantages over electrolysis are that a single operation is sufficient, and that the cure is more speedy and certain. The operation is attended with much less hæmorrhage than might be expected.

Cavernous Angioma.—This form of angioma consists of a series of large blood spaces which are usually derived from the dilatation of the capillaries of a subcutaneous nævus. The spaces come to communicate freely with one another by the disappearance of adjacent capillary walls. While the most common situation is in the subcutaneous tissue, cavernous angiomata are sometimes met with in internal organs. It may appear at any age from early youth to middle life, and is of very slow growth. The swelling is rounded or oval, there is no pulsation or bruit, and the tumour is but slightly compressible. The treatment consists in dissecting out the tumour.

Aneurysm by Anastomosis is the name applied to a vascular tumour in which the arteries, veins, and capillaries are all involved. It is met with chiefly on the upper part of the trunk, the neck, and the scalp. It tends gradually to increase in size, and may, after many years, attain an enormous size. The tumour is ill-defined, and varies in consistence. It is pulsatile, and a systolic bruit or a "thrilling" murmur may be heard over it. The chief risk is hæmorrhage from injury or ulceration.

The *treatment* is conducted on the same lines as for *nævus*. When electrolysis is employed, it should be directed towards the afferent vessels; and if it fails to arrest the flow through these, it is useless to persist with it. In some cases ligation of the afferent vessels has been successful.

Arterial Angioma or Cirsoïd Aneurysm.—This is composed entirely of the enlarged branches of an arterial trunk. The condition originates in the smaller branches of an artery—usually the temporal—and may spread to the main trunk, and

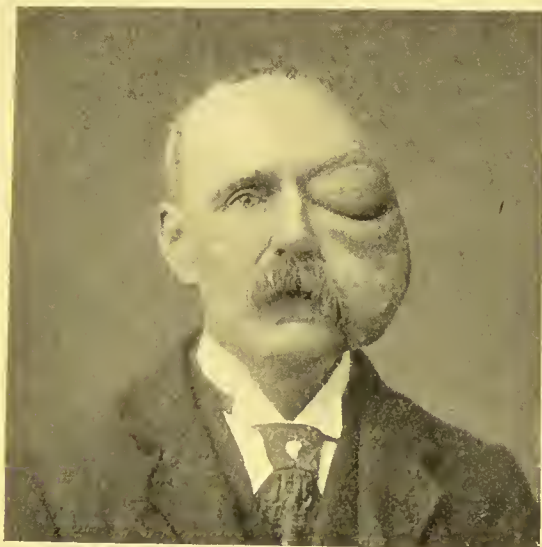


FIG. 70.—Cirsoïd Aneurysm of Orbit and Face, which developed after a blow on the Orbit with a cricket ball.

(From a photograph lent by Mr. J. M. Cotterill.)

may even involve branches of other trunks with which the affected artery anastomoses.

The condition is probably congenital in origin, though its appearance is frequently preceded by an injury. It almost invariably occurs on the head, and is usually met with in adolescents or young adults.

The affected vessels slowly increase in size, and become characteristically tortuous, with narrowings and dilatations here and there. Grooves or gutters are frequently found in the bone underlying the dilated vessels.

There is a constant loud bruit in the tumour, which greatly troubles the patient and may interfere with sleep. There is

no tendency either to natural cure or to rupture, but severe, and even fatal hæmorrhage may follow a wound of the dilated vessels.

The condition may be treated by excision or by electrolysis. In excision the hæmorrhage is controlled by an elastic tourniquet applied horizontally round the head, or by ligation of the feeding trunks. In large tumours the bleeding may be formidable. In many cases electrolysis is to be preferred, and is performed in the same way as for nævus. The positive pole is placed in the centre of the tumour, while the negative is introduced into the main affluents one after another.

ANEURYSM

An aneurysm is a sac communicating with an artery, and containing fluid or coagulated blood.

Two types of aneurysm are met with—the pathological, and the traumatic. It is convenient to describe in this section also certain conditions in which there is an abnormal communication between an artery and a vein—arterio-venous aneurysm.

PATHOLOGICAL ANEURYSM

In this class are included such aneurysms as are produced by gradual dilatation of an artery, resulting from weakening of its coats, combined, in most cases, with a loss of elasticity in the walls and a marked increase in the arterial tension. In the majority of cases the weakening of the artery and the diminution of the normal elasticity of its wall are due to atheroma. In other cases the vessel wall is softened by arteritis—especially the embolic form—so that it yields before the pressure of the blood.

Repeated and sudden raising of the arterial tension, as a result, for example, of violent muscular efforts or of frequent excessive indulgence in alcohol, plays an important part in the causation of aneurysm. These factors probably explain the comparative frequency of aneurysm in those who follow such arduous occupations as soldiers, sailors, dock-labourers, and navvies. In these classes the condition usually manifests itself between the ages of thirty and fifty—that is, when the vessels are beginning to degenerate, although the heart is still vigorous and the men are hard at work. The comparative immunity of women may also be explained by the less

severe muscular strain involved by their occupations and recreations. Any cause that persistently increases the vascular tension also favours aneurysm formation—for example, plethora, chronic alcoholism, gout, or chronic Bright's disease.

Syphilis plays an important part in the production of aneurysm, but the precise way in which it acts is doubtful. It may be that it predisposes the patient to atheroma, and induces a persistent increase in the vascular tension in the peripheral vessels, from loss of elasticity of the vessel wall and narrowing of the lumen as a result of syphilitic arteritis. It is a striking fact that aneurysm is seldom met with in women who have not suffered from syphilis.

Varieties.—Different varieties of pathological aneurysm occur, according as the weakening of the wall is general over a considerable segment of the artery, or is localised in one or more limited areas.

Fusiform Aneurysm.—When the whole circumference of a portion of an artery has been weakened, the tension of the blood causes the walls to dilate uniformly, so that a fusiform or tubular aneurysm results. All the coats of the vessel are stretched and form the sac of the aneurysm, and the affected portion is not only dilated but is also increased in length. This form is chiefly met with in the arch of the aorta, but may occur in any of the main arterial trunks. As the sac of the aneurysm includes all three coats, and as the inner and outer coats are usually thickened by the deposit in them of connective tissue, this variety of aneurysm increases in size very slowly and seldom gives rise to urgent symptoms.

As a rule a fusiform aneurysm contains fluid blood, but when the intima is roughened by atheroma, especially in the form of calcareous plates, shreds of clot may adhere to it.

Natural cure is occasionally effected by the emerging artery becoming occluded by a clot.

Sacculated Aneurysm.—When a limited area of the vessel wall is weakened—for example, by atheroma or by other form of arteritis—this portion yields before the pressure of the blood, and a sacculated aneurysm results. The intima and media being already damaged, or, it may be, destroyed, by the primary disease, the stress falls on the adventitia, which in the majority of cases constitutes the sac. To withstand the pressure the outer coat becomes thickened, and as the aneurysm increases in size it forms adhesions to surrounding tissues, so that fasciæ, tendons, nerves, and other structures may be found matted together in the wall of the aneurysm. The wall is further

strengthened by the deposit on its inner aspect of blood-clot, which may eventually become organised.

The contents of the sac consist of fluid blood, and a varying amount of clot, which is deposited in concentric layers on the inner aspect of the sac, where it forms a pale, striated, firm mass, which constitutes a laminated clot. Near the blood current the clot is soft, red, and friable (Fig. 71). The laminated clot not only strengthens the sac, enabling it to resist the blood pressure and so prevent rupture, but, if it increases sufficiently to fill the cavity, may bring about cure. The principle upon which all methods of treatment are based is to imitate nature in producing such a clot.

An aneurysm is said to be *diffused* when the sac ruptures and the blood escapes into the surrounding tissues.

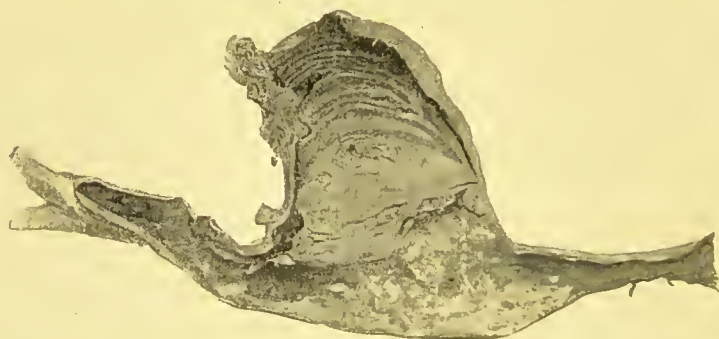


FIG. 71.—Sacculated Aneurysm of Abdominal Aorta nearly filled with laminated clot. Note greater density of clot towards periphery.

When one or more of the coats of the artery enter into the formation of the sac, the aneurysm is sometimes called a “true aneurysm”; while the term “false” is applied when all the coats have given way and the sac is formed entirely by condensation of the surrounding structures. These terms, however, have been used in so many different senses, and are in themselves so misleading, that we do not employ them.

Dissecting Aneurysm.—The blood may force its way between the coats of the vessel—sometimes between the intima and media, but usually into the substance of the media—and so form a cul-de-sac in the substance of the vessel wall. This is spoken of as a dissecting aneurysm. It always originates in the aorta, and is confined to the large branches in the thorax and abdomen, and is not amenable to surgical treatment.

Clinical Features of Aneurysm.—Surgically, the sacculated

is by far the most important variety of aneurysm. The outstanding feature is the existence in the line of an artery of a more or less globular swelling, which pulsates. The pulsation is of an expansile character, which is detected by observing that when both hands are placed over the swelling they are separated with each beat of the heart. If the main artery be compressed on the cardiac side of the swelling, the pulsation is arrested and the tumour becomes smaller and less tense, and it may be still further reduced in size by gentle pressure being made over it so as to empty it of fluid blood. On allowing the blood again to flow through the artery, after one or two beats of the heart the sac fills up and the expansile pulsation returns. In most cases a distinct thrill is felt on placing the hand over the swelling, and a blowing, systolic murmur may be heard with the stethoscope. It is to be borne in mind that occasionally, when the interchange of blood between an aneurysm and the artery from which it arises is small, pulsation and bruit may be very slight or even absent. This is also the case when the sac contains a considerable quantity of clot. When it becomes filled with clot—*consolidated aneurysm*—these signs disappear, and the clinical features are those of a solid tumour lying in contact with an artery, and transmitting its pulsation.

A comparison of the pulse in the artery beyond the seat of the aneurysm with that in the artery on the healthy side, shows that on the affected side the wave is smaller in volume, and somewhat delayed in time. A pulse tracing shows that the normal impulse and diastolic waves are lost, and that the force and rapidity of the tidal wave are diminished.

An aneurysm exerts pressure on the surrounding parts, which are usually thickened and adherent to it and to one another. Adjacent veins may be so compressed that congestion and œdema of the parts beyond are produced. Pain, disturbances of sensation, and muscular paralyses may result from pressure on nerves. Such bones as the sternum and vertebræ may undergo erosion and be absorbed by the gradually increasing pressure of the aneurysm. Cartilage, on the other hand, being elastic, yields before the pressure, so that the intervertebral discs or the costal cartilages may escape while the adjacent bones are destroyed. The skin over the aneurysm gradually becomes thinned and stretched, until finally a slough forms, and when it separates hæmorrhage takes place.

Differential Diagnosis.—Aneurysm is to be diagnosed from other pulsatile swellings. Pulsation is sometimes transmitted

from a large artery to a new growth, a mass of enlarged lymphatic glands, or an inflammatory swelling which lies in its vicinity, but the pulsation is not expansile as in aneurysm—a most important point in differential diagnosis. Such swellings may, by appropriate manipulation, be moved from the artery in some cases and the pulsation ceases, and compression of the artery on the cardiac side of the swelling, although it arrests the pulsation, does not produce any diminution in the size or tension of the swelling, and when the pressure is removed the pulsation is restored immediately.

Fluid tumours overlying an artery, such as cysts, abscesses, or enlarged bursæ, may simulate aneurysm very closely. An apparent expansion may accompany the pulsation, but careful examination usually enables this to be distinguished from the true expansion of an aneurysm. Compression of the artery makes no difference in the size or tension of the swelling.

Vascular tumours, such as sarcomata and goitres, may yield an expansile pulsation and a soft, whiffing bruit, but they differ from an aneurysm in that they are not diminished in size by compression of the main artery, nor can they be emptied by pressure.

The exaggerated pulsation sometimes observed in a normal artery—for example, the “pulsating aorta” so often seen in women who suffer from dyspeptic symptoms—should not be mistaken for that of an aneurysm.

Prognosis.—*Natural cure* of an aneurysm is usually brought about by the formation of laminated clot, which gradually increases in amount till it fills the sac. Sometimes a portion of clot in the sac may be separated and become impacted as an embolus in the artery beyond, leading to thrombosis which first occludes the artery and then extends into the sac.

The progress of natural cure is indicated clinically by the aneurysm becoming smaller, firmer, less expansile, and less compressible. The murmur and thrill are also diminished, and the pressure effects become less marked. When the cure is complete the expansile pulsation is lost, and there remains a firm swelling attached to the vessel (*consolidated aneurysm*). While these changes are taking place the collateral arteries become enlarged, and an anastomatic circulation is established.

An aneurysm may prove *fatal* by exerting pressure on important structures adjacent to it, by causing syncope, by rupture, or from the occurrence of suppuration. *Pressure* symptoms are usually most serious from aneurysms situated in

the neck, thorax, or skull. Sudden fatal *syncope* is not infrequent in cases of aortic and other large aneurysms.

Rupture may take place through the skin, on a mucous or serous surface, or into the cellular tissue. The first hæmorrhage is often comparatively slight and stops naturally, but it soon recurs, and is so profuse, especially when the blood escapes externally or into a large cavity, that it rapidly proves fatal. When the bleeding takes place into the cellular tissue, the aneurysm is said to become *diffused*, and the extravasated blood may spread widely through the tissues, exerting great pressure on the surrounding structures.

The *clinical features* associated with rupture of an aneurysm are sudden and severe pain in the part, the patient becoming pale, cold, and faint. If a comparatively small escape of blood takes place into the tissues, the sudden alteration in the size, shape, and tension of the aneurysm, together with loss of pulsation, may be the only local signs. When the bleeding is profuse, however, the parts beyond the aneurysm become greatly swollen, livid, and cold, and the pulses as a rule are completely lost. At the same time the characteristic signs of aneurysm disappear. The arrest of the blood-supply may result in gangrene. Sometimes the pressure of the extravasated blood causes the skin to slough and, later, give way, and fatal hæmorrhage results.

The *treatment* is carried out on the same lines as for a ruptured artery (p. 270), the main object being to avert gangrene of the limb.

Suppuration may occur in the vicinity of an aneurysm, and the aneurysm may burst into the abscess which forms, so that when the latter points the pus is mixed with broken-down blood-clot, and finally free hæmorrhage takes place. It has more than once happened that even eminent surgeons have incised such abscesses without having recognised their association with aneurysm, with tragic results.

Treatment.—In treating an aneurysm, the indications are: to promote the coagulability of the blood, and so to favour the formation of a clot in the sac; and to obtain a permanent occlusion of the portion of the artery from which the aneurysm springs, without at the same time seriously endangering the nutrition of the parts beyond.

Constitutional Treatment should be tried in the first instance, measures being taken to reduce the arterial tension and to diminish the force of the heart's action. The patient must be kept in bed at absolute rest. A dry and non-stimulating diet

is indicated, the quantity being gradually reduced till it is just sufficient to maintain nutrition. Saline purges may be employed to reduce the vascular tension. The benefit derived from potassium iodide administered in full doses, as first recommended by George W. Balfour, probably depends on its depressing action on the heart. Pain or restlessness may call for the use of opiates.

Local Treatment.—When constitutional treatment fails, local measures must be adopted, and many methods are available.

Extirpation of the Sac—The Old Operation.—The procedure which goes by this name consists in exposing the aneurysm, incising the sac, clearing out the clots, and ligating the artery above and below the sac. In some instances the sac is then dissected out and removed; in others it is left to contract. Where it is available this is the most radical and the most certain method of treatment. Originally practised by Antyllus (A.D. 300)—hence the name “old operation”—the procedure was revived by Syme, and has been widely practised by Annandale and others. This method is particularly suitable to all forms of sacculated aneurysm of the limbs, so long as they are tolerably circumscribed and free from complications. It has been successfully practised also in aneurysm of the subclavian, carotid, and external iliac arteries. It is not applicable to cases in which there is such a degree of atheroma as would interfere with the successful ligation of the artery.

In the neck and in other situations where a tourniquet cannot be employed, the sac must be incised, and a finger quickly passed into the lumen of the artery so as to plug it and prevent bleeding while the clots are being turned out and the ligatures applied. The risk from hæmorrhage renders this one of the most formidable operations of surgery.

In the limbs, the circulation is controlled by a tourniquet—preferably that of Petit, which can be rapidly slackened and tightened as may be necessary. The aneurysm is freely exposed, and, after the vessel has been ligated above and below, the sac is opened and the clots turned out. The sac is then dissected away, any vessels coming off from it being tied, or it is left to contract according to circumstances. If the vein is adherent to the sac, as is frequently the case, the adherent portion may be removed. Experience proves that the removal of a limited portion of both artery and vein at the same time is not necessarily followed by gangrene, so long as infection is excluded.

When, on account of adhesions, there is difficulty in applying the ligature to the artery after opening and emptying the sac, a bougie may be passed into the lumen of the vessel and the ligature thrown round it with the aid of an aneurysm needle, the bougie being withdrawn as the ligature is tightened (Annandale). This manœuvre may be repeated at the distal end.

Endo-aneurysmorrhaphy.—Matas of New Orleans has introduced methods of operating for aneurysm which, in suitable cases, render it possible, while getting rid of the sac, to preserve the lumen of the artery.

Ligation of the Artery.—The principle of this operation is to arrest, or so far to diminish, the flow of blood through the aneurysmal part of the artery, that coagulation takes place in the sac and extends into and occludes the artery.

The ligature may be applied on the cardiac side of the aneurysm, either immediately above the sac (Anel, 1710) or at some distance above (John Hunter, 1785).

Proximal Ligation.—The chief claim of the Hunterian operation is its simplicity, the ligature being applied to a healthy part of the artery whose relations are undisturbed by the proximity of the aneurysm—for example, ligation of the femoral in Scarpa's triangle or in Hunter's canal, for popliteal aneurysm.

By this method the cure is not certain, however, as the distance between the seat of ligation and the sac favours the establishment of a collateral circulation through intervening branches, and this, while it diminishes the risk of gangrene, permits the access of blood to the aneurysm before there is time for an occluding clot to be formed. Even when a clot forms it may be only temporary, and may disappear, so that pulsation in the sac returns. This "recurrent pulsation" after ligation of an artery may be due to imperfect occlusion of the vessel at the seat of ligation, to the rapid establishment of a free collateral circulation, or to the dispersion of the clot which temporarily occluded the artery.

Distal Ligation.—One or more branches may be ligated on the distal side of the aneurysm, so as totally to arrest the flow through the sac (Brasdor, 1760)—for example, in aneurysm of the proximal end of the common carotid the vessel may be ligated near its bifurcation. The distal operation may also be performed merely to diminish the quantity of blood passing through the affected artery without completely stopping the stream (Wardrop, 1825)—for example, in innominate aneurysm the common carotid and third part of the subclavian may be

tied, the branches of the first part of the subclavian not being interfered with.

Compression.—With a view to promoting coagulation in the sac, the circulation may be temporarily arrested by compressing the artery on the cardiac side of the aneurysm. To be efficient the compression must be kept up continuously for several hours, and this is best accomplished by digital pressure applied over a superficial part of the vessel where it overlies a bone. The results, however, are so uncertain that the procedure has been given up almost entirely.

Flexion.—In small and slowly growing aneurysms at the bend of the elbow or in the popliteal space, the circulation may be arrested and coagulation induced by flexing the joint so that the sac is pressed against the artery, and the artery slightly kinked. This method is rarely employed alone, but chiefly as an adjuvant to others, as, for example, when pulsation threatens to return after the Hunterian operation has been performed. Before being flexed, the limb is bandaged up to the level of the aneurysm, and the flexed attitude is maintained for several hours.

Reid's Method by Elastic Bandage.—An elastic bandage is firmly applied from the fingers or toes to just below the aneurysm, it is lightly applied as it passes over the swelling, and again tightened above. As the circulation through the limb is thus completely arrested, the bandage must not be left on for more than an hour, for fear of inducing gangrene. As the bandage is being removed the artery should be controlled by digital pressure to prevent a sudden inflow of blood disturbing the clot which may have formed. This pressure should be maintained for some hours.

Other Methods of Treatment.—In such aneurysms as innominate, aortic, gluteal, or vertebral, which are so situated that the methods already described are impracticable, one or other of the following measures may be employed.

Macewen's acupuncture or "needling" method consists in passing one or more fine, highly tempered steel needles through the tissues overlying the aneurysm, and through its outer wall. The needles are made to touch the opposite wall of the sac, and the pulsation of the aneurysm imparts a movement to them which causes them to scarify the inner surface of the sac. Granulations form on the rough surface produced, and on these the blood coagulates, the clot thus formed increasing in size till it fills the sac. As much of the inner aspect of the sac as can be reached should be scarified in this way, to

increase the area of granulation tissue formation and to render the clot uniformly thick. The needles may be left in position for some hours, the projecting ends being surrounded with sterile gauze.

Electrolysis is applied to an aneurysm in the same way as to a nævus. The insulated needles are passed in the same way as Macewen's needles, and the results seem to be best when the needle is made to scratch the wall of the sac—a combination of "needling" and galvano-puncture.

The *Moore-Corradi method* consists in introducing through the wall of the aneurysm a hollow insulated needle, through the lumen of which from ten to twenty feet of highly drawn silver or other wire is passed into the sac, where it coils up into an open meshwork. The positive pole of a galvanic battery is attached to the wire, and the negative pole placed over the patient's back. A current, varying in strength from twenty to seventy milliampères, is allowed to flow for about an hour. The hollow needle is then withdrawn, but the wire is left *in situ*. The results are somewhat similar to those obtained by needling and by electrolysis, but the clot formed on the large coil of wire is more extensive.

Subcutaneous Injections of Gelatin.—This method of treating inoperable cases of sacculated aneurysm of the large arteries is based on the fact that a solution of gelatin introduced into the circulation increases the coagulability of the blood. Three or four ounces of a 2 per cent. solution of white gelatin in sterilised water, at a temperature of about 100° F., are injected into the subcutaneous tissue of the abdomen every two, three, or four days. In the course of a fortnight or three weeks improvement may begin. The clot which forms is liable to soften and be absorbed, but a repetition of injections has in several cases established a permanent cure.

Amputation of the limb is indicated chiefly in cases complicated by suppuration, by secondary hæmorrhage after excision or ligation, or by gangrene. Amputation at the shoulder was performed by Fergusson in a case of subclavian aneurysm, as a means of arresting the blood-flow through the sac.

TRAUMATIC ANEURYSM

The essential feature of a traumatic aneurysm is that it is produced by some form of injury which divides all the coats of the artery. The walls of the injured vessel are usually healthy, but they form no part of the sac of the aneurysm. The sac

consists of the condensed and thickened soft tissues which surround the artery.

The injury to the artery may be of the nature of a subcutaneous wound or tear, such as is produced by the fragments of a broken bone, or it may be a punctured wound from a stab or cut. Only small wounds of arteries give rise to traumatic aneurysm, as extensive wounds are attended with a sudden and profuse hæmorrhage into the cellular tissue which shows no tendency to become limited.

The aneurysm may form soon after the injury is inflicted; blood slowly escapes into the surrounding tissues, gradually displacing and condensing them, until they form a distinct sac enclosing the effused blood. Towards the periphery the blood coagulates, and, being under considerable pressure, the clot becomes condensed.

Less frequently a traumatic aneurysm forms some consider-



FIG. 72.—Traumatic Aneurysm of Brachial Artery, in a girl æt. 16, caused by stab with pen-knife.

able time after the injury, from gradual stretching of the fibrous cicatrix by which the wound in the wall of the artery has been closed. The gradual stretching of this cicatrix results in condensation of the surrounding structures which form the sac, on the inner aspect of which laminated clot is deposited.

A traumatic aneurysm is almost always sacculated, and, so long as it remains circumscribed, has the same characters as a pathological sacculated aneurysm, with the addition that there may be external evidence of a wound. A traumatic aneurysm is very liable to become diffuse—a change which, although attended with considerable risk of gangrene, has sometimes been the means of bringing about a cure.

The treatment is governed by the same principles as apply to the pathological varieties, but as the walls of the artery are not atheromatous, operative measures dealing with the sac and the adjacent segment of the affected artery are to be preferred.

ARTERIO-VEINous ANEURYSM

An abnormal communication between an artery and a vein constitutes an arterio-venous aneurysm. Two varieties are recognised—one in which the communication is direct—*aneurysmal varix* (Fig. 73); the other in which the vein communicates with the artery through the medium of an aneurysmal sac—*varicose aneurysm* (Fig. 74).



FIG. 73.—Diagram of Aneurysmal Varix.

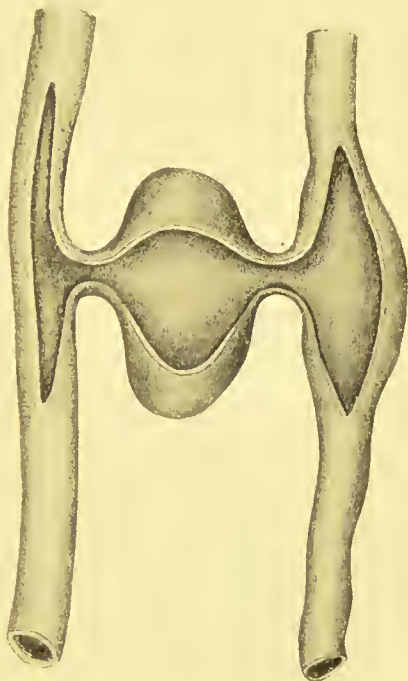


FIG. 74.—Diagram of Varicose Aneurysm.

Either variety may result from pathological causes, but in the vast majority of cases they are traumatic in origin, being due to such injuries as stabs, punctured wounds, and gun-shot injuries which involve both artery and vein. In former times the most common situation was at the bend of the elbow, the brachial artery having been accidentally punctured in blood-letting from the median basilic vein. Arterio-venous aneurysm is a frequent result of injuries by modern high-velocity bullets, for example, in the neck or groin.

In *aneurysmal varix* (Fig. 73) the higher blood pressure in the artery forces arterial blood into the vein, which near the

point of communication with the artery tends to become dilated, and to form a thick-walled sac, beyond which the vessel and its tributaries are distended and tortuous. The clinical features of aneurysmal varix resemble those associated with varicose veins, but the entrance of arterial blood into the dilated veins causes them to pulsate, and produces in them a marked vibratory thrill and a loud murmur.

As the varix tends to remain stationary, in the majority of cases the support of an elastic bandage is all that is required, but when the condition progresses and causes serious inconvenience, it may be necessary to cut down and expose the site of communication between the artery and vein, and, after separating the vessels, to close the opening in each by a fine suture. The operation is difficult and dangerous, and gangrene may ensue. If it is impossible thus to obliterate the communication, the artery should be ligated above and below the point of communication.

Varicose aneurysm (Fig. 74) usually develops in relation to a traumatic aneurysm, the sac becoming adherent to an adjacent vein, and ultimately opening into it. In this way a communication between the artery and the vein is established, and the clinical features are those of a combination of aneurysm and aneurysmal varix.

As there is little tendency to spontaneous cure, and as the aneurysm is liable to increase in size and finally to rupture, operative treatment is usually called for. This consists in applying a ligature to the artery above and below the point of communication, and at the same time incising the sac, turning out the clots, and ligating any branches which open into the sac. If it can be avoided, the vein should not be ligated.

ANEURYSMS OF INDIVIDUAL ARTERIES

Thoracic Aneurysm.—All varieties of aneurysm occur in the aorta, the fusiform being the most common, although a sacculated aneurysm frequently springs from a fusiform dilatation.

The *clinical features* depend chiefly on the direction in which the aneurysm enlarges, and are not always well marked even when the sac is of considerable size. They consist in a pulsatile swelling—sometimes in the episternal notch, but usually towards the right side of the sternum—with an increased area of dulness on percussion. With the X-rays a dark shadow

is seen corresponding to the aneurysm. Pain is usually a prominent symptom, and is largely referable to the pressure of the aneurysm on the vertebral column or the sternum, causing erosion of these bones. Pressure on the thoracic veins and on the air-passages may cause cyanosis and dyspnœa. When the œsophagus is pressed upon, the patient may have difficulty in swallowing. The left recurrent laryngeal nerve may be stretched or pressed upon as it hooks round the arch of the aorta, and hoarseness of the voice and a characteristic "brassy" cough may result from paralysis of the muscles of the larynx which it supplies. The vagus, the phrenic, and the spinal nerves may also be pressed upon. When the aneurysm is on the transverse part of the arch, the trachea is pulled down with each beat of the heart—a clinical phenomenon known as the "tracheal tug." Aneurysm of the descending aorta may, after having eroded the bodies of the vertebræ and posterior portions of the ribs, form a swelling in the back to the left of the spine.

Needling, electrolysis, the Moore-Corradi method, and the subcutaneous injection of gelatin have all been employed with the object of promoting the formation of a clot in the sac and preventing rupture. Christopher Heath found that improvement followed ligation of the left common carotid in aneurysm of the transverse part of the aortic arch.

Abdominal Aneurysm.—Aneurysm is much less frequent in the abdominal than in the thoracic aorta. While any of the large branches in the abdomen may be affected, the most common seats are just above the origin of the cœliac axis, and at the bifurcation.

The *clinical features* vary with the site of the aneurysm and with its rapidity and direction of growth. A smooth, rounded swelling, which exhibits expansile pulsation, forms, usually towards the left of the middle line. It may extend upwards under cover of the ribs, downwards towards the pelvis, or backwards towards the lumbar region. On palpation a systolic thrill may be detected, but the presence of a murmur is neither constant nor characteristic. Pain is usually present; it may be neuralgic in character, or may simulate renal colic. When the aneurysm presses on the vertebræ and erodes them, the symptoms may closely simulate those of spinal caries, particularly if, as sometimes happens, symptoms of compression paraplegia ensue. In its growth the swelling may press upon and displace the adjacent viscera, and so interfere with their functions.

The *diagnosis* has to be made from solid or cystic tumours overlying the artery; from a "pulsating aorta"; and from spinal caries, and much help can be obtained by the use of the X-rays.

The condition usually proves fatal, either by the aneurysm bursting suddenly into the peritoneal cavity, or by slow leakage into the retro-peritoneal tissue.

Electrolysis and the Moore-Corradi method have been successfully employed, access to the sac having been obtained by opening the abdomen. Ligation of the aorta has so far been unsuccessful, but in one case operated upon by Keen the patient survived for forty-eight days.

Innominate aneurysm may be of the fusiform or of the sacculated variety, and is frequently associated with pouching of the aorta. It usually grows upwards and outwards, projecting above the sternum and right clavicle, which may be eroded or displaced by it. Symptoms of pressure on the structures in the neck, similar to those produced by aortic aneurysm, occur. The pulses in the right upper extremity and in the right carotid and its branches are diminished and delayed. Pressure on the right brachial plexus causes shooting pain down the arm and muscular paresis on that side. Vaso-motor disturbances and contraction of the pupil on the right side may result from pressure on the sympathetic fibres. Death may take place from rupture, or from pressure on the air-passages.

The available methods of treatment are ligation of the right common carotid and third part of the right subclavian (Wardrop's operation), of which eight successful cases have been recorded. The cases most suitable for ligation are those in which the aneurysm is circumscribed and globular (Sheen). If ligation is found to be impracticable, needling, electrolysis, or the Moore-Corradi method may be tried.

Carotid Aneurysms.—Aneurysm of the *common carotid* is more frequent on the right than on the left side, and is usually situated either at the root of the neck or near the bifurcation of the artery. It is the aneurysm most frequently met with in women. From its position the swelling is liable to press on the vagus, recurrent laryngeal and sympathetic nerves, on the air-passages, and on the œsophagus, giving rise to symptoms referable to such pressure. There may be cerebral symptoms from interference with the vascular supply of the brain.

Aneurysm near the origin of the common carotid has to be diagnosed from subclavian, innominate, and aortic aneurysm, and from other swellings—solid or fluid—met with in the

neck. It is often difficult to determine with precision the trunk from which an aneurysm at the root of the neck originates, and not infrequently more than one vessel shares in the dilatation. A careful consideration of the position in which the swelling first appeared, of the direction in which it has progressed, of its pressure effects, and of the condition of the pulses beyond, may help in distinguishing between aortic, innominate, carotid, and subclavian aneurysms. Skiagraphy is also of assistance in recognising the vessel involved.

Tumours of the thyroid, enlarged lymphatic glands, and fatty and sarcomatous tumours can usually be distinguished from aneurysm by the history of the swelling and by careful physical examination. Cystic tumours and abscesses in the neck are sometimes more difficult to differentiate on account of the apparently expansile character of the pulsation transmitted to them. The fact that compression of the vessel does not affect the size and tension of these fluid swellings is useful in distinguishing them.

Treatment.—Digital compression of the vessel against the transverse process of the sixth cervical vertebra—the “carotid tubercle”—has been successfully employed in the treatment of aneurysm near the bifurcation. Proximal ligation in the case of high aneurysms, or distal ligation in those situated at the root of the neck, is more certain. Extirpation of the sac is probably the best method of treatment, especially in aneurysms of traumatic origin. These operations are attended with considerable risk of hemiplegia from interference with the blood supply of the brain.

The *external carotid* and the cervical portion of the *internal carotid* are seldom the primary seat of aneurysm, although they are liable to be implicated by the upward spread of an aneurysm at the bifurcation of the common trunk. In addition to the ordinary signs of aneurysm, the clinical manifestations are chiefly referable to pressure on the pharynx and larynx, and on the hypoglossal nerve. When the hypoglossal nerve is implicated, the corresponding side of the tongue is paralysed. Aneurysm of the internal carotid is of special importance on account of the way in which it bulges into the pharynx in the region of the tonsil, in some cases closely simulating a tonsillar abscess. Cases are on record in which such an aneurysm has been mistaken for an abscess and incised, with disastrous results.

The most satisfactory method of treatment, when it is practicable, is by proximal ligation.

Aneurysmal varix may occur in the neck as a result of stabs

or bullet wounds. The communication is usually between the common carotid artery and the internal jugular vein. The resulting interference with a cerebral circulation causes headache, giddiness, and other brain symptoms, and a persistent loud murmur is usually a source of great annoyance to the patient. If operative treatment is called for, the artery should be ligated above and below the point of communication.

Intracranial aneurysm may involve the internal carotid and its branches, or the basilar artery, and appears to be more frequently associated with syphilis and with valvular disease of the heart than are external aneurysms. They are seldom diagnosed from other intracranial tumours during life, as they give rise to no characteristic symptoms, save, in some cases, a loud murmur. They usually prove fatal by rupture and intracranial hæmorrhage. The treatment is to ligate the common carotid or the vertebral artery in the neck according to the seat of the aneurysm.

Orbital Aneurysm.—The term pulsating exophthalmos is employed clinically to embrace a number of pathological conditions, including aneurysm, in which the chief symptoms are a marked pulsation in the orbit, and protrusion of the eyeball. There may be, in addition, congestion and œdema of the contents of the orbit and of the eyelids, and a distinct thrill and murmur, which can be controlled by compression of the common carotid in the neck. Varying degrees of ocular paralysis and of interference with vision may also be present.

These symptoms are due, in the majority of cases, to aneurysmal varix of the internal carotid artery and cavernous sinus, which is often traumatic in origin, being produced either by fracture of the base of the skull or by a punctured wound through the orbit. In other cases they are due to aneurysm of the ophthalmic artery, to thrombosis of the cavernous sinus, and, in rare instances, to cirroid aneurysm.

If compression of the common carotid is found to arrest the pulsation, ligation of this vessel is indicated.

Subclavian Aneurysm.—Subclavian aneurysm is usually met with in men who follow occupations involving excessive use of the shoulder—for example, dock-porters and coal-heavers. It is more common on the right side.

The aneurysm usually springs from the third part of the artery, and appears as a tense, rounded, pulsatile swelling just above the clavicle and to the outer side of the sterno-mastoid muscle. It occasionally extends in the direction of the thorax, where it may become adherent to the pleura. The radial pulse

on the same side as the aneurysm is small and delayed. Congestion and œdema of the arm, with pain, numbness, and muscular weakness, may result from pressure on the veins and nerves as they pass under the clavicle; and pressure on the phrenic nerve may induce hiccough. The aneurysm is of slow growth, and occasionally undergoes spontaneous cure.

The conditions most likely to be mistaken for subclavian aneurysm are a soft, rapidly growing sarcoma, and a normal artery raised on a cervical rib. It is to be borne in mind, however, that aneurysm is liable to develop in an artery so displaced by a cervical rib.

On account of the relations of the artery and of its branches, surgical treatment is attended with greater difficulty and danger in subclavian than in almost any other form of external aneurysm. Needling or electrolysis should be tried. The available operative measures are proximal ligation of the innominate, and distal ligation. In some cases it has been found necessary to combine distal ligation with amputation at the shoulder-joint, to prevent the collateral circulation maintaining the flow through the aneurysm. Matas' operation has been successfully performed by Hogarth Pringle.

Axillary Aneurysm.—Any part of the axillary artery may be the seat of aneurysm. It is usually met with in the right arm of labouring men and sailors, and not infrequently follows an injury in the region of the shoulder. The vessel may be damaged by the head of a dislocated humerus or in attempts to reduce the dislocation, by the fragments of a fractured bone, or by a stab or cut. Sometimes the vein also is injured and an arterio-venous aneurysm established.

Owing to the laxity of the tissues, an axillary aneurysm grows more rapidly than a subclavian, and it may soon attain a large size, filling up the axilla, and displacing the clavicle upwards. This renders compression of the third part of the subclavian difficult or impossible. It may extend beneath the clavicle into the neck, or, extending inwards, may form adhesions with the chest wall, and, after eroding the ribs, with the pleura.

The usual symptoms of aneurysm are present, and the pressure effects on the veins and nerves are similar to those produced by an aneurysm of the subclavian. Intra-thoracic complications, such as pleurisy or pneumonia, are not infrequent when the aneurysm forms adhesions to the chest wall and pleura. Rupture may take place externally, into the shoulder-joint, or into the pleural cavity.

Extirpation of the sac is the operation of choice, but, if this is impracticable, ligation of the third part of the subclavian may be had recourse to.

Brachial aneurysm usually occurs at the bend of the elbow, is of traumatic origin, and is best treated by excision of the sac.

Aneurysmal varix, which was frequently met with in this situation in the days of the barber-surgeons,—usually as a result of the artery having been accidentally wounded while performing venesection of the median basilic vein,—may be treated, according to the amount of discomfort it causes, by a supporting bandage, or by ligation of the artery above and below the point of communication.

Aneurysms of the vessels of the **forearm and hand** call for no special mention; they are almost invariably traumatic, and are treated by excision of the sac.

Inguinal Aneurysm (*Aneurysm of the Iliac and Common Femoral Arteries*).—Aneurysms appearing in the region of Poupart's ligament may have their origin in the external or common iliac arteries or in the common femoral. On account of the tension of the fascia lata, they tend to spread upwards towards the abdomen, and, to a less extent, downwards into the thigh. Sometimes a constriction occurs across the sac at the level of Poupart's ligament.

The pressure exerted on the nerves and veins of the lower extremity causes pain, congestion, and œdema of the limb beyond. Rupture may take place either externally, or into the cellular tissue of the iliac fossa.

These aneurysms have to be diagnosed from pulsating sarcomata growing from the pelvic bones, and from an abscess, or mass of enlarged lymphatic glands overlying the artery and transmitting pulsation.

Electrolysis or needling may be considered, but the method of treatment which has met with most success has been ligation of the common or external iliac, reached either by reflecting the peritoneum from off the iliac fossa (extra-peritoneal operation), or by going through the peritoneal cavity (trans-peritoneal operation).

Gluteal Aneurysm.—An aneurysm in the buttock may arise from the gluteal or from the sciatic artery, but by the time it forms a salient swelling it is seldom possible to recognise by external examination in which vessel it takes origin. The special symptoms to which it gives rise are pain down the limb from pressure on the sciatic nerves, and interference with the movements at the hip.

Ligation of the internal iliac by the trans-peritoneal route is the most satisfactory method of treatment, but these aneurysms are also amenable to treatment by needling or electrolysis. Extirpation of the sac is difficult and dangerous, especially when the aneurysm has spread into the pelvis.

Femoral Aneurysm.—Aneurysm of the superficial femoral artery is usually traumatic in origin, and is more common in Scarpa's triangle than in Hunter's canal. Any of the methods already described is available for their treatment—the choice lying between ligation of the external iliac and extirpation of the sac.

Aneurysm of the *profunda femoris* is distinguished from aneurysm of the main trunk by the fact that the pulses beyond are, in the former, unaffected, and by the normal artery being felt pulsating over or alongside of the sac.

In *aneurysmal varix*, a not infrequent result of a bullet wound or a stab, the communication with the vein may involve the superficial or the deep femoral artery. Should operative interference become necessary as a result of progressive increase in size of the tumour, or progressive distension of the veins of the limb as a whole, an attempt should be made to separate the vessels concerned and to close the opening in each by a fine suture. If this is impracticable, the artery is tied above and below the communication; gangrene of the limb may supervene, and we have observed a case in which the gangrene extended as high as the junction of the middle and lower thirds of the thigh.

Popliteal Aneurysm.—Popliteal aneurysm is the most common surgical aneurysm, and is not infrequently met with in both limbs. It is generally due to disease of the artery, although repeated slight strains, which are so liable to occur at the knee, may play an important part in determining its formation. In former times it was very common in post-boys, from the repeated flexion and extension of the knee in riding.

The aneurysm is usually of the sacculated variety, and may spring from the front or from the back of the vessel. It may exert pressure on the bones and ligaments of the joint, and it has been known to open into the articulation. The pain, stiffness, and effusion into the joint which accompany these changes often lead to an erroneous diagnosis of joint disease. The sac may press upon the popliteal artery or vein, causing congestion and œdema of the leg, and leading to gangrene. Pressure on the popliteal nerves gives rise to severe pain, muscular cramp, and weakness of the leg.

The differential diagnosis is to be made from abscess, bursal cyst, enlarged glands, and sarcoma.

The choice of operation lies between ligation of the femoral artery in Hunter's canal, enucleation of the sac, and Matas' operation of aneurysmo-arteriorraphy. The success which attends the Hunterian operation is evidenced by the fact that Syme performed it thirty-seven times without a single failure. If it fails, the old operation should be considered, but it is a much more serious operation, and one which is more liable to be followed by gangrene of the limb. Experience shows that ligation of the vein, or even the removal of a portion of it, is not necessarily followed by gangrene if the wound remains aseptic.

Aneurysmal varix is sometimes met with in the region of the popliteal space. It is characterised by the usual symptoms, and is treated by palliative measures, or by ligation of the artery above and below the point of communication.

Aneurysm in the **leg and foot** is rare. It is almost always traumatic, and is treated by excision of the sac.

CHAPTER XV

THE LYMPHATICS

Anatomy and physiology—INJURIES OF LYMPHATIC VESSELS: *Wounds of thoracic duct*—DISEASES OF LYMPHATIC VESSELS—Lymphangitis: *Varicities*—Lymphangiectasis—Filarial disease—Lymphangioma—DISEASES OF LYMPHATIC GLANDS—Lymphadenitis: *Septic; Tuberculous; Syphilitic*—Lymphadenoma—Leucocythæmia—TUMOURS.

LYMPH is essentially blood plasma which has passed through the walls of capillaries. After bathing and nourishing the tissues, it is collected by lymphatic vessels, which return it to the blood-stream by way of the thoracic duct. These lymphatic vessels take origin in the lymphatic spaces of the tissues and in the walls of serous cavities, and they usually run alongside blood-vessels—*perivascular lymphatics*. They have a structure similar to that of veins, but are more abundantly provided with valves. Along the course of the lymphatic trunks are the *lymphatic glands*, which possess a definite capsule and are composed of a reticulated connective tissue, the spaces of which are packed with leucocytes. The glands act as filters, arresting not only inert substances, such as blood pigment circulating in the lymph, but also living elements, such as cancer cells or bacteria. As it passes through a gland the lymph is brought into intimate contact with the leucocytes, and in bacterial infections there is always a struggle between the organisms and the leucocytes, so that the glands may be looked upon as an important line of defence, retarding or preventing the passage of bacteria and their products into the general circulation. The infective agent, moreover, in order to reach the blood-stream, must usually overcome the resistance of several glands.

Lymphatic glands are, for the most part, arranged in groups or chains, such as those in the axilla, neck, and groin. In any given situation they vary in number and size in different individuals, and fresh glands may be formed on comparatively slight stimulus, and disappear when the stimulus is withdrawn. The best-known example of this is the increase in the

number of glands in the axilla which takes place during lactation; when this function ceases, many of the glands become involuted and are transformed into fat, and in the event of a subsequent lactation they are again developed. After glands have been removed by operation, new ones may be formed.

Anatomical Distribution of Glands.—The more important groups of glands, and the areas which they drain, in the head and neck and in the upper and lower extremities, are as follows:—

Head and Neck.—*The parotid or pre-auricular glands* lie beneath the parotid fascia in front of the ear, and some are partly embedded in the substance of the parotid gland; they drain the parts about the temple, cheek, eyelids, and auricle. It is quite common for them to become the seat of tuberculous disease. *The occipital gland*, situated over the origin of the trapezius from the superior curved line, drains the top and back of the head; it is very rarely affected. *The mastoid or posterior auricular glands* lie over the mastoid process, and drain the side of the head and auricle. These three groups pour their lymph into the cervical glands. *The submaxillary*—two to six in number—lie along the lower border of the jaw from the symphysis to the angle, the posterior ones being closely connected with the submaxillary salivary gland. They receive lymph from the face, lips, floor of the mouth, gums, teeth, anterior part of tongue, and the alæ nasi, and from the pre-auricular glands. The lymph passes from them into the deeper cervical glands. They are very frequently infected with tubercle and with epithelioma which has spread to them from the mouth. *The submental glands* lie in or close to the middle line between the anterior bellies of the digastric muscles, and receive lymph from the lips. It is rare for them to be the seat of tubercle, but in epithelioma of the lower lip and floor of the mouth they are infected at an early stage of the disease. *The supra-hyoid* lies a little farther back, immediately above the hyoid bone, and receives lymph from the tongue. *The external jugular glands*, when present, lie along the external jugular vein, and receive lymph from the occipital and mastoid glands and from the auricle. *The sterno-mastoid glands*—*glandulæ concatenatæ*—form a chain along the posterior edge of the sterno-mastoid muscle, some of them lying beneath the muscle. They are commonly enlarged in constitutional syphilis. *The internal jugular glands*, commonly called the deep cervical,—from six to twenty in number,—form a continuous chain along the internal jugular vein, beneath the sterno-mastoid muscle. They drain the various groups of glands which lie nearer the surface, also the

interior of the skull, the larynx, trachea, thyroid, and lower part of the pharynx, and pour their lymph into the main lymphatic trunks at the root of the neck. Belonging to this group is one large gland which lies behind the posterior belly of the digastric, and rests in the angle between the internal jugular and common facial veins. It is commonly enlarged in affections of the tonsil and posterior part of the tongue. In the same group are three or four glands which lie entirely under cover of the upper end of the sterno-mastoid muscle, and surround the spinal accessory nerve before it perforates the muscle. The deep cervical glands are very commonly infected by tubercle and also by epithelioma secondary to disease in the tongue or throat. *The supra-clavicular glands* lie in the posterior triangle, above the clavicle. They receive lymph from the lowest cervical glands, from the upper part of the chest wall, and from the highest axillary glands. They are frequently infected in cancer of the breast; those on the left side also in cancer of the stomach. The removal of diseased supra-clavicular glands is not to be lightly undertaken, as difficulties are liable to ensue in connection with the thoracic duct, the pleura, or the junction of the subclavian and internal jugular veins. *The retro-pharyngeal glands* lie on each side of the middle line upon the rectus capitis anticus major muscle and in front of the prevertebral layer of the cervical fascia. They receive part of the lymph from the posterior wall of the pharynx, the interior of the nose and its accessory cavities, the Eustachian tube, and the tympanum. When they are infected with pyogenic organisms or with tubercle bacilli, they may lead to the formation of one form of retro-pharyngeal abscess.

Upper Extremity.—*The epi-trochlear and ante-cubital glands* vary in number, that most commonly present lying about an inch and a half above the internal condyle, and other and smaller glands may lie along the internal bicipital sulcus or at the bend of the elbow. They drain the ulnar side of the hand and forearm, and pour their lymph into the axillary group. The epi-trochlear gland is sometimes enlarged in syphilis. *The axillary glands* are arranged in groups: a central group lie embedded in the axillary fascia, and are often related to an opening in it; a subscapular group lie along the line of the subscapular vessels; pectoral groups lie behind the pectoralis minor, along the inner side of the axillary vein, and between the two pectoral muscles. The axillary glands receive lymph from the arm, mamma, and side of the chest, and pass it on into the lowest cervical glands and the main lymphatic trunk.

They are frequently the seat of pyogenic, tuberculous, and cancerous infection, and their complete removal is an essential part of the operation for cancer of the breast.

Lower Extremity.—*The popliteal glands* include one superficial gland at the termination of the short saphenous vein, and several deeper ones in relation to the popliteal vessels. They receive lymph from the toes and foot, and transmit it to the inguinal glands. *The femoral glands* lie vertically along the upper part of the internal saphenous vein, and receive lymph from the leg and foot; from them the lymph passes to the deep inguinal and external iliac glands. The femoral glands often participate in pyogenic infections entering through the skin of the toes and sole of the foot. *The superficial inguinal glands* lie along Poupart's ligament, and receive lymph from the external genitals, anus, perineum, buttock, and anterior abdominal wall. The lymph passes on to the deep inguinal and external iliac glands. The superficial glands through their relations to the genitals are frequently the subject of venereal infection, and also of epithelioma when this disease affects the genitals or anus; they are rarely the seat of tuberculosis. *The deep inguinal glands* lie on the inner side of the femoral vein, and sometimes within the crural canal. They receive lymph from the deep lymphatics of the lower limb, and some of the efferent vessels from the femoral and superficial inguinal glands. The lymph then passes on through the crural canal to the external iliac glands. The extension of malignant disease, whether cancer or sarcoma, can often be traced along these deeper lymphatics into the pelvis, and as the obstruction to the flow of lymph increases there is a corresponding increase in the swollen dropsical condition of the lower limb on the same side.

The glands of the *thorax* and *abdomen* will be considered with the surgery of these regions.

INJURIES OF LYMPHATIC VESSELS

Lymphatic vessels are divided in all wounds, and the lymph that escapes from them is added to any discharge that may be present. In injuries of larger trunks the lymph may escape in considerable quantity as a colourless, watery fluid—*lymphorrhagia*; and the opening through which it escapes is known as a *lymphatic fistula*. This has been observed chiefly after extensive operations for the removal of malignant glands in the groin, and in such cases the lymph, including that which has accumulated in the vessels of the limb, may escape in such

abundance as to soak through large dressings and delay the healing of the wound. Ultimately new lymph channels are formed, so that at the end of from four to six weeks the discharge of lymph ceases and the wound heals.

When the lymphatic return from a limb has been seriously interfered with,—as, for example, when the axillary contents have been completely cleared out in operating for cancer of the breast,—a condition of *lymphatic œdema* may result, the arm becoming swollen, tight, and heavy.

Wounds of the Thoracic Duct.—The thoracic duct usually opens at the angle formed by the junction of the left internal jugular and subclavian veins, but it may open into either of these vessels by one or by several channels, or the duct may be double throughout its course. There is a smaller duct on the right side—the right thoracic duct. The duct or ducts may be displaced by a tumour or a mass of enlarged glands, and may be accidentally wounded in dissections at the root of the neck; jets of milky fluid—chyle—may at once escape from it. The jets are rhythmical and coincide with expiration. The injury may, however, not be observed at the time of operation, but later through the dressings being soaked with chyle—*chylorrhœa*. If the wound involves the only existing main duct and all the chyle escapes, the patient suffers from intense thirst, emaciation, and weakness, and may die of inanition; but if, as is usually the case, only one of several collateral channels is implicated, the loss of chyle may be of little moment, as the discharge usually ceases spontaneously. If the wound heals so that the chyle is prevented from escaping, a fluctuating swelling may form beneath the scar, and in course of time gradually disappear.

It is rarely possible to close an accidental wound of the duct with sutures, the vessel should therefore be tied preferably by suture as if it were a bleeding artery. The tissues are then stitched over it and the skin wound accurately closed, so as to obtain primary union, firm pressure being applied by dressings and an elastic webbing bandage. Even if the main duct is obliterated, a collateral circulation is usually established. A wound of the right lymphatic duct is of less importance.

Subcutaneous rupture of the thoracic duct may result from a crush of the thorax. The chyle escapes and may accumulate in the cellular tissue of the posterior mediastinum and behind the peritoneum, in the pleural cavity (*chylo-thorax*), or in the peritoneal cavity (*chylous ascites*). There are physical signs of fluid in one or other of these situations, but, as a rule, the

nature of the lesion is only recognised when chyle is withdrawn by the exploring needle.

DISEASES OF LYMPHATIC VESSELS

Lymphangitis.—Inflammation of peripheral lymphatic vessels usually results from the entrance of pyogenic infection from some primary source in the skin. This may be a septic wound or a purulent blister, and the streptococcus pyogenes is the organism most frequently present. Septic lymphangitis is commonly met with in those who, from the nature of their occupation, handle infective material. A *gonococcal lymphangitis* has been observed in those suffering from gonorrhœa.

The inflammation affects chiefly the walls of the vessels, and is attended with clotting of the lymph. There is also some degree of inflammation of the surrounding cellular tissue—*peri-lymphangitis*. One or more abscesses may form along the course of the affected vessels, or a spreading cellulitis may supervene.

The *clinical features* resemble those of other acute pyogenic infections, and there are wavy red lines running from the source of infection towards the nearest lymphatic glands. These correspond to the inflamed vessels, and are the seat of burning pain and tenderness. The associated glands are enlarged and painful. In severe cases the symptoms may merge into those of septicæmia. When the deep lymphatics alone are involved, the superficial red lines are absent, but the limb becomes swollen and pits on pressure.

In cases of extensive lymphangitis, especially when there are repeated attacks, the vessels may be obliterated by the formation of new connective tissue and a persistent solid œdema result, culminating in one of the forms of elephantiasis.

Treatment.—The primary source of infection is dealt with on the usual lines. If the lymphangitis is confined to one of the extremities, Bier's elastic bandage is applied, and if suppuration occurs, the pus is let out through one or more small incisions; in other parts of the body Klapp's suction bells are employed. The streptococcus may be cultivated from the pus and a vaccine prepared therefrom injected. When the condition has subsided, the limb is massaged and evenly bandaged to prevent œdema, or, if present, to promote its disappearance.

Tuberculous Lymphangitis.—Although lymphatic vessels play an important rôle in the spread of tuberculosis, the

clinical recognition of the disease in lymphatic vessels is exceptional. It is met with chiefly in relation to tuberculous lesions of the skin of the extremities, such as lupus, inoculation tubercle, and sinuses resulting from dactylitis. The infection spreads upwards along the superficial lymphatics, which become nodularly thickened; at one or more points, larger, peri-lymphangitic nodules may form and break down into abscesses and ulcers. When the disease is widely distributed throughout the lymphatics, the limb becomes swollen and hard—a condition illustrated by lupus elephantiasis.

Syphilitic lymphangitis is observed in cases of primary syphilis, in which the vessels of the dorsum of the penis can be felt as indurated cords.

In addition to acting as channels for the conveyance of bacterial infection, *lymphatic vessels frequently convey the cells of malignant tumours*, and especially cancer, from the seat of the primary disease to the nearest lymphatic glands, and they may themselves become the seat of cancerous growth forming nodular cords (Fig. 97). This is of great importance in relation to the eradication of cancer by operative measures.

Lymphangiectasis is a dilated or varicose condition of lymphatic vessels. It is sometimes met with as a congenital affection in the tongue and lips, or it may be acquired as the result of any condition which is attended with extensive obliteration or blocking of the main lymphatic trunks. An interesting type of lymphangiectasis is that which results from the presence of the *filaria sanguinis hominis* in the vessels, and is observed chiefly in the groin, spermatic cord, and scrotum of persons who have lived in the tropics.

Filarial disease in the lymphatics of the groin appears as a soft, doughy swelling, varying in size from a walnut to a cocoa-nut; it may partly disappear on pressure and when the patient lies down.

The patient may give a history of feverish attacks during which the swelling becomes painful and tender. These attacks may show a remarkable periodicity, and each may be followed by an increase in the size of the swelling, which may extend along the inguinal canal into the abdomen, or down the spermatic cord into the scrotum. On dissection, the swelling is found to be made up of dilated, tortuous, and thickened lymphatic vessels in which the parent worm is sometimes found, and of greatly enlarged lymphatic glands which have become converted into a spongy tissue, the spaces of which are filled with lymph. The fluid in the dilated vessels is

either clear or turbid, in the latter case resembling chyle. The affection is frequently bilateral, and may be associated with lymph scrotum, with elephantiasis, and with chyluria.

The *diagnosis* is to be made from such other swellings in the groin as hernia, lipoma, or cystic pouching of the saphena vein. It is confirmed by finding the embryos of the filariæ in the blood.

Treatment.—When the disease is generalised throughout the body, operation is contra-indicated. When it is limited to the groin or scrotum, excision may bring about a permanent cure, especially if the adult worms are found in the lymphatics that are removed; but it may result in the formation of lymphatic sinuses and only afford temporary relief.

Lymphangioma.—A lymphangioma consists of a series of cavities and channels filled with lymph and freely communicating with one another. The cavities result either from the new formation of lymphatic spaces or vessels, or from the dilatation of those which already exist; their walls are composed of fibro-areolar tissue lined by endothelium and sometimes strengthened by non-striped muscle. They are rarely provided with a definite capsule, and frequently send prolongations of their substance between and into muscles and other structures in their vicinity. They are of congenital origin, and usually make their appearance at or shortly after birth. When the tumour is made up of a meshwork of caverns and channels, it is called a *cavernous lymphangioma*; when it is composed of one or more separate cysts, it is called a *cystic lymphangioma*. It is probable that the cysts are derived from the caverns by the breaking down and absorption of the intervening septa, and transition forms between the cavernous and cystic varieties are met with.

The *cavernous lymphangioma* appears as an ill-defined, soft swelling, presenting many of the characters of a subcutaneous nævus, but it is not capable of being emptied by pressure, and if the tumour is punctured with an exploring needle, it yields lymph instead of blood. It also resembles a lipoma, especially the congenital variety which grows from the periosteum, and the differential diagnosis between these is rarely completed until the swelling is punctured or explored by operation. If treatment is called for, it is carried out on the same lines as for nævus, by means of electrolysis, igni-puncture, or excision. Complete excision is rarely possible because of the want of definition and encapsulation.

The *cystic lymphangioma*, *lymphatic cyst*, or *congenital cystic hygroma*, is most often met with in the neck—*hydrocele of the neck*; it is situated beneath the deep fascia, and projects either in front of or behind the sterno-mastoid muscle. It may attain a very large size, the overlying skin and cyst wall may be so thin as to be translucent, and it has been known to cause serious impairment of respiration through pressing on the trachea. In the axilla also the cystic tumour may attain a



FIG. 75—Congenital Cystic Tumour or Hygroma of Axilla.

(From a photograph lent by Dr. Lediard.)

considerable size (Fig. 75); less frequent situations are the groin, and the floor of the mouth where it constitutes one form of ranula.

The nature of these swellings is to be recognised by their situation, by their having existed from infancy, and, if necessary, by drawing off some of the contents of the cyst through a fine needle. They are usually remarkably indolent, persisting often for a long term of years without change, and, like nævus, they sometimes undergo spontaneous shrinkage and cure.

Sometimes the cystic tumour becomes infected and forms an abscess—another, although less desirable, method of cure. Those situated in the neck are most liable to suppurate, probably because of pyogenic organisms being brought to them by the lymphatics taking origin in the scalp, ear, or throat. If operative interference is called for, the cyst may be tapped and injected with iodine, or excised; the operation of removal may entail a considerable dissection amongst the deeper structures at the root of the neck, and should not be lightly undertaken.

DISEASES OF LYMPHATIC GLANDS

Lymphadenitis.—Inflammation of lymphatic glands results from the advent of an irritant, usually bacterial or toxic, brought to the glands by the afferent lymphatics. These vessels may share in the inflammation and be the seat of lymphangitis, or they may show no evidence of the passage of the noxa. It is exceptional for the irritant to be carried to the gland in the blood-stream.

A strain or other form of trauma is sometimes blamed for the onset of lymphadenitis, especially in the glands of the groin (bubo), but it is usually possible to discover some source of pyogenic infection which is responsible for the mischief, or to obtain a history of some antecedent affection such as gonorrhœa. It is possible for gonococci to lie latent in the inguinal glands for long periods, and only give rise to lymphadenitis if the glands be subsequently subjected to injury. The glands most frequently affected are those in the neck, axilla, and groin.

The characters of the lymphadenitis vary with the nature of the irritant. Sometimes it is mild and evanescent, as in the glandular enlargement in the neck which attends tonsillitis and certain other forms of sore throat. Sometimes it is more persistent, as in the enlargement which may be associated with adenoids, hypertrophied tonsils, carious teeth, eczema of the scalp, and otorrhœa; and it is probable that this indolent enlargement predisposes to tuberculous infection. A similar enlargement is met with in the axilla in cases of chronic interstitial mastitis, and in the groin as a result of chronic irritation about the external genitals.

Sometimes the lymphadenitis is of a more acute character, and the tendency is towards the formation of an abscess. This is illustrated in the axillary glands inflamed as a result of

infected wounds of the fingers; in the femoral glands in infected wounds or purulent blisters on the foot; in the inguinal glands in gonorrhœa and soft chancre; and in the cervical glands in the severer forms of sore throat associated with diphtheria and scarlet fever. The most acute glandular suppurations result from infection with streptococci.

Superficial glands, when inflamed and suppurating, become enlarged, tender, fixed, and matted to one another. In the glands of the groin the suppurative process is often remarkably sluggish; purulent foci form in the interior of the individual glands, and some time may elapse before the pus erupts through their respective capsules. In the deeply placed cervical glands, especially in cases of streptococcal throat infections, the suppuration rapidly involves the surrounding cellular tissue, and the clinical features are those of an acute cellulitis and deeply seated abscess. When this is incised the necrosed glands may be found lying in the pus, and on bacteriological examination are found to be swarming with streptococci. In suppuration of the axillary glands the abscess may be quite superficial, or it may be deeply placed beneath the strong fascia and pectoral muscles, according to the group of glands involved.

The *diagnosis* of septic lymphadenitis is usually easy. The indolent enlargements are not always to be distinguished, however, from commencing tuberculous disease, except by the use of the tuberculin test, and by the fact that they usually disappear on removing the peripheral source of irritation.

Treatment.—The first indication is to discover and deal with the original source of infection, and in the indolent forms of lymphadenitis this will usually be followed by recovery. In the more acute forms following on pyogenic infection, the best results are obtained from the hyperæmic treatment carried out by means of suction bells. If suppuration is not thereby prevented, or if it has already taken place, each separate collection of pus is punctured with a narrow-bladed knife and the use of the suction bell is persevered with. If there is a large periglandular abscess, as is often the case, in the neck and axilla, the opening may require to be made by Hilton's method, and it may be necessary to insert a drainage-tube.

Tuberculous Disease of Glands.—This is a disease of great frequency and importance. The tubercle bacilli usually gain access to the glands through the afferent lymphatic vessels, which convey them from some lesion of the surface within the area which they drain. It is possible, however, that

the organisms sometimes reach the glands by the blood-stream. Tuberculous infection may supervene in glands which are already enlarged as a result of chronic septic irritation. While any of the glands in the body may be affected, the disease is most often met with in the cervical groups which derive their lymph from the mouth, nose, throat, ear, and scalp.

The appearance of the glands on section varies with the stage of the disease. In the early stages the gland is enlarged, it may be to many times its natural size, is normal in appearance and consistence, and as there is no peri-adenitis it is easily shelled out from its surroundings. On microscopical examination, however, there is evidence of infection in the shape of bacilli and of characteristic giant and epithelioid cells. At a later stage, the gland tissue is studded with minute yellow foci which tend to enlarge and in time to become confluent, so that the whole gland is ultimately converted into a caseous mass. This caseous material is surrounded by the thickened capsule which, as a result of peri-adenitis, tends to become adherent to and fused with surrounding structures, and particularly with layers of fascia and with the walls of veins. The caseated tissue often remains unchanged for long periods; it may become calcified, but more frequently it liquefies and breaks down into tuberculous pus.

Tuberculous disease in the cervical glands is a common accompaniment or sequel of adenoids, enlarged tonsils, carious teeth, pharyngitis, middle-ear disease, conjunctivitis, and suppurative lesions of the scalp, such as impetigo. These lesions afford the bacilli a chance of entry into the lymphatics, in which they are carried to the glands, where they give rise to tuberculous disease.

The enlargement may affect only one gland, usually below the angle of the jaw, and remain confined to it, the gland reaching the size of a hazel nut, and being ovoid, firm, and painless. More commonly the disease affects several glands, on one or on both sides of the neck. When the disease commences in the pre-auricular or submaxillary glands, it tends to spread to those along the carotid sheath; when the posterior auricular and occipital glands are first involved, the spread is to those along the posterior border of the sterno-mastoid. In many cases all the chains in front of, beneath, and behind this muscle are involved, the enlarged glands extending from the mastoid to the clavicle. When several glands are affected, they are at first discrete and

movable, and may even vary in size from time to time ; but with the addition of peri-adenitis they become fixed and matted together, forming large lobulated or nodular masses. They become adherent not only to one another, but also to the structures in their vicinity—and notably to the internal jugular vein—a point of importance in regard to their removal by operation.

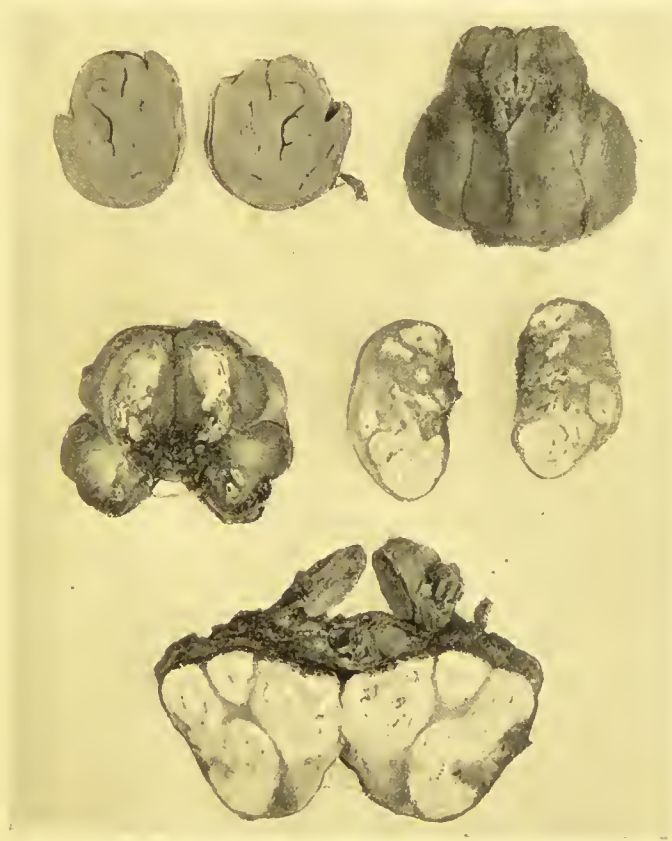


FIG. 76.—Tuberculous Glands showing progressive stages of disease : enlarged ; studded with tuberculous foci ; caseous.

At any stage the progress of the disease may be arrested and the glands may remain for long periods without further change. It is possible that the tuberculous tissue may undergo cicatrization. More commonly suppuration ensues, and a cold abscess forms, but if there is a mixed infection, the pyogenic factor being usually derived from the throat, it may take on

more active features. The transition from the solid to the liquefied stage is attended with pain and tenderness in the gland, which at the same time becomes fixed and more globular, and finally fluctuation can be elicited.

If left to itself, the softened tubercle erupts through the capsule of the gland and infects the cellular tissue. The cervical fascia is perforated, and a cold abscess, often much larger than the gland from which it took origin, forms between the fascia and the overlying skin. The further stages—reddening, undermining of skin and external rupture, with the formation of ulcers and sinuses—have been described with tuberculous abscess. The ulcers and sinuses may persist indefinitely, or may heal and then break out again; and sometimes the skin becomes the seat of tuberculous disease, which may spread like lupus, especially in the submaxillary region, until it eventually extends from ear to ear. Healing may finally take place after all the caseous tubercle has been extruded, and the resulting scars are extremely unsightly, being puckered or bridled, or highly coloured and hypertrophied like keloid.

While the disease is most common in childhood and youth, it may be met with even in advanced life; and although commonly associated with impaired health and unhealthy surroundings, it may affect those who are apparently robust and are in affluent circumstances.

Diagnosis.—If there is no obvious cause of glandular enlargement, the presumption is that the condition is tuberculous, and it will usually be possible to confirm this by one or other of the tuberculin tests. These tests may also serve to differentiate tuberculous disease from lympho-sarcoma and from lymphadenoma, but if any doubt remains, one of the glands should be removed and submitted to microscopical examination. Signs of liquefaction and suppuration support the diagnosis of tubercle. Other forms of sarcoma, and the enlargement of an accessory thyroid, are less likely to be confused with tuberculous glands.

Enlargement of the cervical glands from secondary cancer may simulate tuberculosis—especially when the cancerous glands have undergone liquefaction—but is differentiated by its association with cancer in the mouth, throat, or other adjacent part, and by the early induration and fixation of the affected glands.

The cold abscess which results from tuberculous glands is to be distinguished from that due to disease in the cervical

spine, retro-pharyngeal abscess, as well as from congenital and other cystic swellings in the neck.

Prognosis.—Next to lupus, glandular disease is of all tuberculous lesions the least dangerous to life. Nevertheless, a certain proportion of those who suffer from it in childhood or youth afterwards suffer from tuberculous disease in the bones or joints, and in internal organs, especially the lungs.

Treatment.—The conditions vary so widely in different cases that no one line of treatment can be expected to suffice in all: every case must be considered and dealt with on its own merits.

When seen in the quiescent stage, before there are any signs of liquefaction, it is advisable to remove any irritation in the mouth or throat, and improve the general health by fresh air, good food, and cod-liver oil. If the glandular enlargement persists, and especially if it is on the increase, and there is evidence of extension to other glands, removal by operation should be recommended. External applications such as iodine or mercurial ointment should be avoided.

The excision of tuberculous glands is often an extensive and difficult operation, because of the number and deep situation of the glands to be removed, and of the adhesions to surrounding structures. The skin incision must be sufficiently extensive to give access to the whole of the affected area, and to avoid disfigurement, should, whenever possible, be made in the line of the natural creases of the skin. When glands are to be removed from both anterior and posterior triangles, the best access is obtained by a Z-shaped incision, the upper limb running parallel with the lower jaw, the vertical limb along the sterno-mastoid, and the lower limb parallel with the clavicle. In exposing the glands the common facial and other venous trunks may require to be clamped and tied. Care must be taken not to injure the important nerves, particularly the spinal accessory, the vagus, and the phrenic. The inframaxillary branches of the facial, the hypoglossal and its descending branches, and the motor branches of the deep cervical plexus are also liable to be injured. The dissection is rendered easier and is attended with less risk of injury to the nerves, if, instead of a knife, the conical scissors of Mayo are employed. In the removal of matted glands beneath the sterno-mastoid, it may be necessary to cut this muscle across and to reflect the divided ends upwards and downwards; if the muscle itself is infiltrated with tubercle, the affected portion is removed along

with the glands. When the glandular mass is closely adherent to the internal jugular vein, the operation is rendered easier by ligating the vein at the root of the neck and removing it from below upwards along with the glands (Watson-Cheyne). When the glands are extensively affected on both sides of the neck, it is advisable to allow an interval to elapse rather than to operate on both sides at one sitting. In closing the wound, the platysma and cervical fascia should be reunited by means of a fine



FIG. 77.—Enlarged Tuberculous Axillary Glands.

catgut suture and the skin edges brought together by Michel's clips; if drainage is called for, a very fine glass tube should be introduced through the skin and fascia at a little distance from the main wound.

If the tonsils are enlarged they should not be removed at the same time as the glands as this entails a risk of the operation wound being infected from the throat.

When there are *signs of liquefaction* in the gland, or of a *cold abscess* in the tissues around, the pus should be aspirated

through a hollow needle, the cavity filled with iodoform and glycerin, and the needle puncture closed by a Michel's clip.

When the skin is broken and caseous tuberculous tissue is exposed, healing is promoted by cutting away diseased skin, removing the granulation tissue with the sharp spoon and packing the cavity with iodoform worsted. Exposure to the X-rays is often beneficial in these cases. The treatment of sinuses has already been considered.

Tuberculous disease in the axillary glands may be a result of extension from the glands in the neck, from tuberculous disease of the mamma, ribs, or sternum, or more rarely from tuberculous disease in the fingers or skin of the arm. Sometimes it is impossible to discover the source of infection, in which case we can only assume that it has taken place through the blood-stream. The glands frequently attain a large size, and are usually freely movable. The treatment consists in removing them by an operation similar to that employed in clearing out the contents of the axilla in cases of cancer of the breast.

In the **glands of the groin** tuberculous disease is comparatively rare. We have chiefly observed it in the femoral glands as a result of inoculation tubercle on the toes or sole of the foot. The affected glands nearly always break down and suppurate, and after destroying the overlying skin give rise to fungating ulcers. The treatment consists in excising the glands and the affected skin. The dissection may be attended with troublesome hæmorrhage from the numerous veins that converge towards the common femoral trunk.

Tuberculous affections of the *mesenteric* and *bronchial glands* are described with the surgery of regions.

Syphilitic Disease of Glands.—Enlargement of lymphatic glands is a prominent feature in acquired syphilis, especially in the form of the indolent or bullet-bubo, which so commonly accompanies the primary lesion, and the general enlargement of glands that occurs throughout the body in secondary syphilis. Gummatous disease in glands is extremely rare, although it is slightly more common in the inherited than in the acquired form of the disease. The affected gland rapidly enlarges to the size of a walnut, and may then persist for a long period without further change; if it breaks down, the overlying skin is destroyed and the caseated tissue of the gumma exposed.

Lymphadenoma.—*Hodgkin's Disease* (Pseudo-leukæmia of German authors).—This is a rare disease which is chiefly

met with in young subjects, and is characterised by a painless enlargement of some particular group of glands, most commonly those in the cervical region (Fig. 78). The glands are usually larger than in tuberculosis, and they remain longer discrete and movable; they are firm in consistence, and on section present a granular appearance due to overgrowth of the connective-tissue framework. In time the glandular masses may form enormous projecting tumours, the swelling being added to by œdema of the overlying cellular tissue and skin.

The enlargement spreads along the chain of glands to those above the clavicle, to those in the axilla, and to those of the opposite side (Fig. 79). Later, the glands in the groin become enlarged, and it is probable that the infection has spread from the neck along the mediastinal, bronchial, retroperitoneal, and mesenteric glands, and has branched off to the iliac and inguinal groups.



FIG. 78.—Chronic Hodgkin's Disease in a boy æt. 11.

Two clinical types are recognised, one in which the disease progresses slowly and remains confined to the cervical glands for two or more years; the other, in which the disease is more rapidly

disseminated and causes death in from twelve to eighteen months.

When the disease becomes generalised, the patient's health suffers and he is feverish and anæmic. The blood presents the characters met with in secondary anæmia, and polynuclear leucocytosis is not an essential feature of the disease but an evidence of secondary infection. The spleen, liver, testes, and mammæ may be enlarged. The glandular swellings may press on important structures, such as the trachea, œsophagus, or great veins, and give rise to symptoms referable to such pressure. The origin of the disease is as yet unknown, but analogy would suggest that it is due to infection with a slowly growing micro-organism.

Diagnosis.—Considerable difficulty attends the diagnosis of lymphadenoma at an early stage. The negative results of tuberculin tests may assist in the differentiation from tuberculous disease, but we recommend the more certain means of excising one of the suspected glands and submitting it to microscopical examination. Lympho-sarcoma can usually be differentiated by the rapid assumption of the local features of malignant disease; the enlargement associated with leucocythæmia by the characteristic changes in the blood; and the diffuse enlargement met with in syphilis by the presence of other evidences of that disease.

Treatment.—In acute cases of lymphadenoma, treatment is of little avail. Arsenic may be given in full doses either by the mouth or by subcutaneous injection; the intravenous administration of salvarsan may be given a trial. Excision of glands, although sometimes beneficial, seldom arrests the progress of the disease. The ease and rapidity with which large masses of glands may be shelled out is in remarkable contrast to what is observed in tuberculous disease. Surgical interference may give relief when important structures are being pressed upon—tracheotomy, for example, may be required where life is threatened by asphyxia.

Leucocythæmia.—This is

a disease of the blood and of the blood-forming organs, in which there is a great increase in the number, and an alteration of the character, of the leucocytes present in the blood. It may simulate lymphadenoma, because, in certain forms of the disease, the lymphatic glands, especially those in the neck, axilla, and groin, are greatly enlarged, and there is a gradual failure of health.



FIG. 79.—Advanced Hodgkin's Disease in a boy æt. 5.

(From Byrom Bramwell's *Atlas of Clinical Medicine*.)

TUMOURS OF LYMPHATIC GLANDS

Primary Tumours.—*Lympho-sarcoma*, which may be regarded as a sarcoma starting in a lymphatic gland, appears in the neck, axilla, or mediastinum, as a rapidly growing tumour consisting of one enlarged gland with numerous satellites. As the tumour increases in size, the sarcomatous tissue erupts through the capsule of the glands, and infiltrates



FIG. 80.—Cancerous Glands in Neck secondary to Epithelioma of Lip.

(Mr. G. L. Chiene's case.)

the surrounding tissues, whereby it becomes fixed to these and to the skin.

The disease is an extremely fatal one, and the only hope is in early excision, followed by the use of the X-rays.

Secondary Tumours.—Next to tuberculosis, *secondary cancer* is the most common disease of lymphatic glands. In the neck it is met with in association with epithelioma of the lip, tongue, or throat. The glands form tumours of variable size, and are

often larger than the primary growth, the characters of which they reproduce. The glands are at first movable and hard, but soon become fixed, and in time they soften, liquefy, and burst through the skin, forming foul, fungating ulcers. A similar condition is met with in the groin from epithelioma of the penis, scrotum, or vulva. In cancer of the breast, the infection of the axillary glands is an important complication.

In *pigmented* or *melanotic cancers* of the skin, the glands are early infected and increase rapidly, so that, when the primary growth is still of small size—as, for example, on the sole of the foot—the femoral glands may already constitute large pigmented tumours.

The implication of the glands in other sites and varieties of cancer will be considered with regional surgery.

Secondary sarcoma is seldom met with in lymphatic glands except when the primary growth is situated in the tonsil, thyroid, or testicle.

CHAPTER XVI

THE NERVES

Anatomy.—WOUNDS OF NERVES: Changes in nerves after division; Repair and its modifications; Clinical features; *Primary and secondary suture*—SUBCUTANEOUS INJURIES OF NERVES—DISEASES: *Neuritis; Tumours*—Surgery of the individual nerves: *Brachial neuralgia; Sciatica; Trigeminal neuralgia*.

Anatomy.—A nerve-trunk is made up of a variable number of bundles of nerve fibres surrounded and supported by a framework of connective tissue. The nerve fibres are chiefly of the medullated type, and they run without interruption from a nerve cell or *neuron* in the brain or spinal cord to their peripheral terminations in muscle, skin, and secretory glands.

Each nerve fibre consists of a number of nerve fibrils collected into a central bundle—the axis cylinder—which is surrounded by an envelope, the neurilemma or sheath of Schwann. Between the neurilemma and the axis cylinder is the medullated sheath composed of a fatty substance known as myelin. This medullated sheath is interrupted at the nodes of Ranvier, and in each internode is a nucleus lying between the myelin and the neurilemma. The axis cylinder is the essential conducting structure of the nerve, while the neurilemma and the myelin act as insulating agents. The axis cylinder depends for its nutrition on the central neuron with which it is connected, and from which it originally developed.

The connective-tissue framework of a nerve-trunk consists of the *perineurium*, or general sheath, which surrounds all the bundles; the *epineurium*, surrounding individual groups of bundles; and the *endoneurium*, a delicate connective tissue separating the individual nerve fibres. The blood-vessels and lymphatics run in these connective-tissue sheaths.

According to Head and his co-workers, Sherren and Rivers, the afferent fibres in the peripheral nerves can be divided into three systems:—

1. Those which subserve *deep sensibility* and conduct the impulses produced by pressure. The fibres of this system run with the motor nerves, and pass to muscles, tendons, and joints. Even division of both the ulnar and the median nerves above the wrist produces little loss of deep sensibility, unless the tendons are also cut through. The failure to recognise this form of sensibility has been largely responsible for

the conflicting statements as to the sensory phenomena following operations for the repair of divided nerves.

2. Those which subserve *protopathic* sensibility, that is, are capable of responding to painful cutaneous stimuli and to the extremes of heat and cold. These also endow the hairs with sensibility to pain.

3. Those which subserve *epicritic* sensibility, the most highly specialised, capable of appreciating light touch as a well-localised sensation, and the finer grades of temperature, called cool and warm (72–104° F.), and of discriminating as separate the points of a pair of compasses 2 cms. apart.

INJURIES OF NERVES

Nerves are liable to be cut or torn across, bruised, compressed, stretched, or torn away from their connections with the spinal cord.

Complete division is a common result of accidental wounds, especially above the wrist, where the ulnar, median, and radial nerves are frequently cut across.

The mere interruption of the continuity of a nerve results in degeneration of its fibres, the myelin being broken up into droplets and absorbed, while the axis cylinders swell up, disintegrate, and finally disappear. Both the conducting and the insulating elements are thus lost. The degeneration in the central end of the divided nerve is usually limited to the immediate proximity of the lesion, and does not even involve all the nerve fibres. In the distal end, it is generally believed to extend throughout the entire peripheral distribution of the nerve, and to be due to the cutting off of the fibres from their trophic nerve cells in the spinal cord. If there is a gap left between them, or if they are separated by scar tissue, the peripheral end undergoes complete degeneration in from six weeks to two months.

Process of Repair when the Ends are in Contact.—*If the wound is aseptic*, the ends of the divided nerve become united, and the conducting paths are re-established by a regeneration of nerve fibres. There is a difference of opinion as to the method of regeneration. Most authorities support the Wallerian doctrine, that the axis cylinders in the central end grow downwards, and enter the nerve sheaths of the distal portion, and continue growing until they reach the peripheral terminations in muscle and skin, and in course of time acquire a myelin sheath; the cells of the neurilemma multiply and form long chains in both ends of the nerve, and are believed to provide for the nourishment and support of the actively lengthening axis cylinders. The other view is that the

formation of new axis cylinders is not confined to the central end, but that it goes on also in the peripheral segment, in which, however, the new axis cylinders do not attain maturity until continuity with the central end has been re-established.

If the wound becomes infected and suppuration occurs, the young nerve fibres are destroyed and efficient regeneration is prevented; the formation of scar tissue also may constitute a permanent obstacle to new nerve fibres bridging the gap.

When the ends are not in contact, reunion of the divided

nerve fibres does not take place whether the wound is septic or aseptic. At the proximal end there forms a bulbous swelling, which becomes adherent to the general scar tissue. It consists of branching axis cylinders running in all directions, these having failed to reach the distal end because of the extent of the gap and the presence of scar tissue. The peripheral end is completely degenerated, and is represented by a fibrous cord, the cut end of which is often slightly swollen or bulbous, and is also incorporated with the scar tissue of the wound.



FIG. 81.—Stump Neuromata of Sciatic Nerve, excised forty years after the original amputation by Mr. A. G. Miller.

In the case of nerves divided in an amputation, there is an active, although necessarily abortive, attempt at regeneration, which results in the formation of bulbous swellings at the cut ends of the nerves.

When there has been suppuration, and especially if the nerves have been cut so as to be exposed in the wound, these bulbous swellings may attain an abnormal size, and are then known as “amputation” or “stump neuromata” (Fig. 81).

When a nerve is only partly divided, those fibres which are severed form new axis-cylinder processes, which are conducted across the gap by the intact fibres, and, provided the wound is aseptic, the conducting paths are re-established. In septic wounds the reparative process is usually incomplete, on account of the formation of scar tissue between the ends of the divided fibres.

When a nerve is *torn across* or badly *crushed*—as, for example, by a fractured bone—the changes are very similar to those in a divided nerve, and the ultimate result depends on the amount of separation between the ends and the possibility of the young axis cylinders bridging the gap.

Contusion of a nerve-trunk is attended with extravasation of blood into the connective-tissue sheaths, and is followed by degeneration of the contused nerve fibres. Function is usually restored, the conducting paths being re-established by the formation of new nerve fibres.

Symptoms resulting from Division and Non-Union of a Nerve-Trunk.—These necessarily vary with the functions of the affected nerve. We shall take as an example a mixed sensori-motor trunk, such as the median or musculo-spiral nerve.

Sensory Phenomena.—Superficial touch is tested by means of a wisp of cotton wool stroked gently across the skin; the capacity of discriminating two points as separate, by a pair of blunt-pointed compasses; the sensation of pressure, by means of a pencil or other blunt object; of pain, by means of a needle; and of sensibility to heat and cold, by test-tubes containing water at different temperatures. While these tests are being carried out, the patient's eyes are screened off.

After division of a nerve containing sensory fibres, there is an area of absolute cutaneous insensibility to touch (anæsthesia), to pain (analgesia), and to all degrees of temperature—*loss of protopathic sensibility*; surrounded by an area of loss of sensation to light touch, minor differences of temperature (72–104° F.), and discrimination of the two points of a compass—*loss of epicritic sensibility* (Head and Sherren) (Figs. 87, 89).

Motor Phenomena.—There is immediate and complete loss of voluntary power in all the muscles supplied by the divided nerve. The muscles rapidly waste, and within from three to five days they cease to react to the faradic current. When tested with the galvanic current, it is found that a stronger current must be used to call forth contraction than in a healthy muscle, and the contraction appears first at the closing of the circuit when the anode is used as the testing electrode. The loss of excitability to the interrupted current, and the specific alteration in the type of contraction with the constant current, is known as the *Reaction of Degeneration*. After a few weeks all electric excitability is lost. The paralysed muscles undergo fatty degeneration, which attains its maximum three or four months after the division of the nerve. Further changes may

take place, and result in the transformation of the muscle into fibrous tissue, which by undergoing shortening may cause deformity known as *paralytic contracture*.

Vaso-motor Phenomena.—In the majority of cases there is an initial rise in the temperature of the part (2° to 3° F.), with redness and increased vascularity. This is followed by a fall in the local temperature, which may amount to 8° or 10° F., the parts becoming pale and cold. Sometimes the hyperæmia resulting from vaso-motor paralysis is more persistent, and is associated with swelling of the parts from œdema—the so-called *angio-neurotic œdema*. The vascularity varies with external influences, and in cold weather the parts present a bluish appearance.

Trophic Phenomena.—Owing to the disappearance of the subcutaneous fat, the skin is generally smooth and thin, and it may be abnormally dry. The hair is harsh, dry, and easily shed. The nails may become brittle and furrowed, or thick and curved, and the ends of the fingers become club-shaped. Skin eruptions, especially in the form of blisters, may occur, or there may be actual ulcers of the skin, especially in winter (Fig. 18). In aggravated cases the tips of the fingers may disappear from progressive ulceration, and in the sole of the foot a perforating ulcer may develop. Arthropathies are occasionally met with, the joints becoming the seat of a painless effusion or hydrops, which is followed by fibrous thickening of the capsular and other ligaments, and terminates in stiffness and fibrous ankylosis. In this way the fingers may be seriously crippled and deformed.

When a nerve is *incompletely divided*, the injury may produce the most varying results upon muscular power and on the reaction to electrical stimulation. In many cases the muscles supplied by the injured nerve do not lose voluntary power, and they react normally to both forms of electrical stimulation. Voluntary power may remain while reaction to the interrupted current is lost; the muscles will then respond more readily to the constant current. The contraction still occurs to the negative pole more readily than to the positive, and the strength of current necessary to cause contraction is considerably reduced. This facile reaction to the constant current also occurs when voluntary power is lost and all response to the interrupted current is abolished. It is therefore a valuable indication that the nerve has not been completely severed (Head and Sherren).

Treatment of Divided Nerves.—The treatment consists in

approximating the divided ends of the nerve and placing them under the most favourable conditions for repair, and this should be done at the earliest possible opportunity.

Primary Suture.—The reunion of a recently divided nerve is spoken of as primary suture, and for its success asepsis is essential. As the suturing of the ends of the nerve is extremely painful, an anæsthetic is required. The wound must be enlarged in the long axis of the affected nerve, as the ends—especially the proximal end—are usually retracted. The ends, having been identified, are brought into contact, and secured to each other by the finest chromicised catgut or silk, passed by a round needle such as is used for the intestine. The sutures are made to transfix the ends of the nerve and the sheath, and should only be drawn tight enough to obtain accurate apposition. Additional sutures may be passed through the sheath. The sutured nerve may be enclosed in a de-epithelialised bone tube or the sterilised artery of a dog or calf. If the ends of the nerve are bruised or torn, fresh surfaces should be obtained by cutting them across. If the nerve is only partly divided, it may be sufficient to pass a few sutures through the sheath. Tension on the sutures may be relieved by flexing adjacent joints and fixing the limb in a splint. When the wound is healed and while waiting for the restoration of function, measures are employed to maintain the nutrition of the damaged nerve and of the parts supplied by it. The limb is exercised, massaged, and douches, and protected from cold and other injurious influences. The nutrition of the paralysed muscles is further improved by electricity. The galvanic current is employed, using at first a mild current of not more than five milliampères for about ten minutes, the current being made to flow downwards in the course of the nerve, with the positive electrode applied to the spine, and the negative over the affected nerve near its termination. It is an advantage to have a key in the circuit whereby the current can be opened and closed at intervals, so as to cause contraction of the muscles.

The results of primary suture, when it has been performed under favourable conditions, are usually satisfactory. In a series of cases investigated by Head and Sherren, the period between the operation and the first return of sensation averaged 65 days. The length of time necessary for the return of sensibility to light touch and intermediate degrees of temperature varied, but in the majority of cases it was about one year. The return of voluntary motor power in the paralysed muscles

and of their contractility to the interrupted current averaged 346 days. When sensation returns, the area of insensibility to pain steadily diminishes and disappears; sensibility to extremes of temperature appears very soon after; and last of all, after a considerable interval, there is simultaneous return of appreciation of light touch, moderate degrees of temperature, and the points of a compass.

Primary suture should not be attempted so long as the wound shows signs of infection, as it is almost certain to end in failure. The ends should be sutured, however, as soon as the wound is aseptic or has healed.

Secondary Suture.—The term secondary suture is applied to the operation of stitching the ends of the divided nerve after the wound has healed. This operation is difficult if the ends are involved in scar tissue. An incision is made in the line of the nerve, and the ends sought for. If they cannot be identified, the nerve should be exposed at a little distance above and below, and then traced into the scar. The ends of the nerve, after being freed from the scar, are trimmed with scissors and approximated by sutures.

Results of Secondary Suture.—When secondary suture has been performed under favourable conditions, the prognosis is good, but a much longer time is required for restoration of function than after primary suture. Sensation is recovered first, but it seldom returns before three or four months. There then follows an improvement or disappearance of any trophic disturbances that may be present. Recovery of motion may be deferred for long periods—rather because of the changes in the muscles than from want of conductivity in the nerve—and if the muscles have undergone complete degeneration, it may never take place at all. While waiting for recovery, every effort should be made to maintain the nutrition of the damaged nerve, and of the parts which it supplies.

When suture is found to be impossible, recourse must be had to other methods. For example, the gap may be bridged across by strands of fine catgut or by a portion of nerve obtained from a recently amputated limb. When catgut is employed, it is a useful addition to slip a decalcified bone tube over the ends of the nerve and across the gap. The practice of turning down flaps from the ends of the nerve is of doubtful value, as such portions usually degenerate. Resection of a portion of the humerus to shorten the segment of limb and so diminish the gap between the ends of the nerve was practised by Annandale. When the gap between the ends is very wide,

the ends may be spliced into the nearest intact nerve-trunk—for example, the widely separated ends of the median may be attached to the ulnar, an incision being made through the sheath of this nerve at each point of attachment. The results of this procedure—which has been called *nerve implantation*—are often most satisfactory.

Injuries of nerves resulting from gun-shot wounds may be considered under two heads:—(1) those in which the nerve is directly damaged by the bullet, and (2) those in which the nerve-trunk is involved secondarily either by scar tissue in its vicinity or by callus following fracture of an adjacent bone. The primary injuries include contusion, partial or complete division, and perforation of the nerve-trunk. One of the most constant symptoms is the early occurrence of severe neuralgic pain, and this is usually associated with marked hyperæsthesia. Operative treatment is indicated if the nerve has been divided or if it is involved in scar tissue. The liberation of a nerve from adhesions has been termed *neurolysis*.

Involvement of Nerves in Scar Tissue.—Pressure or traction may be exerted upon a nerve by contracting scar tissue, or a process of neuritis or perineuritis may be induced.

When terminal filaments are involved in a scar, it is best to dissect out the scar, and along with it the ends of the nerves pressed upon. When a nerve-trunk, such as the sciatic, is involved in cicatricial tissue, the nerve must be exposed and freed from its surroundings, and then stretched so as to tear any adhesions that may be present above or below the part exposed. It may be advisable to displace the liberated nerve from its original position so as to minimise the risk of its incorporation in the scar of the original wound or in that resulting from the operation; for example, the musculo-spiral nerve may be buried in the substance of the triceps.

When the nerves in an amputation stump have not been cut sufficiently short, they may become involved in the cicatrix, and it may be necessary, on account of pain, to free them from their adhesions, and to resect enough of the terminal portions to prevent them again becoming adherent. When this is difficult, a portion may be resected from each of the nerve-trunks at a higher level; and if this fails to give relief, a fresh amputation may be performed. When there is agonising pain dependent upon an ascending neuritis, it may be necessary to resect the corresponding posterior nerve roots within the spinal canal.

Subcutaneous Injuries of Nerves.—Several varieties of sub-

cutaneous injuries of nerves are met with. One of the best known is the compression paralysis of the nerves of the upper arm which results from sleeping with the arm resting on the back of a chair or the edge of a table—the so-called “drunkard’s palsy”; and from the pressure of a crutch in the axilla—“crutch paralysis.” A similar form of paralysis is sometimes met with from the pressure of a tourniquet, from tight bandages or splints, from the pressure exerted by a dislocated bone or by excessive callus, and from hyper-extension of the arm during anæsthesia.

In all these forms there is impaired sensation, rarely amounting to anæsthesia, marked muscular wasting, and diminution or loss of voluntary motor power, while—and this is a point of great importance—the normal electrical reactions are preserved. There may also develop trophic changes such as blisters, superficial ulcers, and clubbing of the tips of the fingers. The prognosis is usually favourable, as spontaneous recovery is the rule within from one to three months. If, however, neuritis supervenes, the electrical reactions are altered, the muscles degenerate, and recovery may be retarded or may fail to take place.

Injuries which act abruptly or instantaneously are illustrated in the crushing of a nerve by the sudden displacement of a sharp-edged fragment of bone, as may occur in comminuted fractures of the humerus. The symptoms include perversion or loss of sensation, motor paralysis, and atrophy of muscles, which show the reaction of degeneration from the eighth day onwards. The presence of the reaction of degeneration influences both the prognosis and the treatment, for it implies a nerve lesion which is probably incapable of spontaneous recovery, and which can only be remedied by operation.

The *treatment* varies with the cause and nature of the lesion. When, for example, a displaced bone or a mass of callus is pressing upon the nerve, steps must be taken to relieve the pressure, by operation if necessary. When there is reason to believe that the nerve is severely crushed or torn across, it should be exposed by incision, and, after removal of the damaged ends, should be united by sutures. When it is impossible to make a definite diagnosis as to the state of the nerve, it is better to expose it by an exploratory operation, and thus learn the exact state of affairs without delay; in the event of the nerve being torn, the ends should at once be united by sutures.

Dislocation of Nerves.—This injury, which resembles the

dislocation of tendons from their grooves, is seldom met with except in the ulnar nerve at the elbow, and is described with injuries of this nerve.

DISEASES OF NERVES

Traumatic Neuritis.—This consists in an overgrowth of the connective-tissue framework of a nerve, which causes irritation and pressure upon the nerve fibres, sometimes resulting in their degeneration. It may originate in connection with a wound in the vicinity of a nerve, as, for example, when the brachial nerves are involved in scar tissue subsequent to an operation for clearing out the axilla for cancer; or in contusion and compression of a nerve—for example, by the pressure of the head of the humerus in a dislocation of the shoulder. Some weeks or months after the injury, the patient complains of increasing hyperæsthesia and of neuralgic pains in the course of the nerve. The nerve is very sensitive to pressure, and, if superficial, may be felt to be swollen. The associated muscles are wasted and weak, and are subjected to convulsive twitchings. There are also trophic disturbances. It is rare to have complete sensory and motor paralysis. The disease is commonest in the nerves of the upper extremity, and the hand is often crippled and useless.

Treatment.—Any constitutional condition which predisposes to neuritis, such as gout, diabetes, or syphilis, must receive appropriate treatment. The symptoms may be relieved by rest and by soothing applications, such as belladonna or menthol, by the use of hot-air and electric baths, and in obstinate cases by blistering or by the application of Corrigan's button. When such treatment fails the nerve may be stretched, or, in the case of a purely sensory trunk, a portion may be excised. Local causes, such as involvement of the nerve in a scar or in adhesions, may afford indications for operative treatment.

Multiple Peripheral Neuritis.—Although this disease mainly comes under the cognisance of the physician, it may be attended with phenomena which call for surgical interference.

It may result from a number of causes, acting singly or in combination. In this country it is most commonly due to alcoholism, but it may result from diabetes or from chronic poisoning with lead or arsenic, or from bacterial infections and intoxications such as occur in diphtheria, gonorrhœa,

syphilis, leprosy, typhoid, influenza, beri-beri, and many other diseases.

It is, as a rule, widely and symmetrically distributed throughout the peripheral nerves, but the distribution frequently varies with the cause—the alcoholic form, for example, mainly affecting the legs, the diphtheric form the soft palate and pharynx, and that associated with lead-poisoning the forearms. The essential lesion is a degeneration of the conducting fibres of the affected nerves, and the prominent symptoms are the result of this. The sensory phenomena include numbness and tingling, especially in the fingers and toes, and pain and tenderness along the nerves; complete anæsthesia is rare. The motor phenomena include weakness or actual paralysis of muscles, with wasting, loss of the tendon reflexes, and, in advanced cases, the reaction of degeneration. In alcoholic neuritis there is great tenderness of the muscles. When the legs are affected the patient may be unable to walk, and the toes may droop and the heel be drawn up, resulting in one variety of pes equino-varus. Pressure sores and perforating ulcer of the foot are the most important trophic phenomena.

Apart from the medical *treatment*—which includes the use of remedies directed towards the cause of the neuritis, and for the relief of pain—measures must be taken to prevent deformity, especially when the legs are affected. The bed-clothes are supported by a cage, and the foot maintained at right angles to the leg by sand-bags or splints. When the disease is subsiding, the nutrition of the damaged nerves and muscles should be maintained by massage, baths, passive movements, and the use of the galvanic current.

NEUROMATA¹

Neuroma is a clinical term applied to all tumours, irrespective of their structure, which have their seat in nerves.

Tumours composed of newly formed nerve tissue are spoken of as **true neuromata**; when ganglionic cells are present in addition to nerve fibres, the name *ganglionic neuroma* is applied. These tumours are rare, and are chiefly met with in the main cords or abdominal plexuses of the sympathetic system of children or young adults. They may be solitary or multiple, circumscribed or diffused, and they are quite insensitive. Their

¹ We have followed the classification adopted by Alexis Thomson in his work *On Neuroma and Neuro-fibromatosis*. Edinburgh: 1900.

removal is only called for if they cause inconvenience or show signs of malignancy.

The **false neuromata** are connective-tissue overgrowths of the sheaths of nerves. This overgrowth may result in the formation of a circumscribed tumour, or may take the form of a diffuse fibromatosis.

The circumscribed or solitary tumours grow from the sheaths of nerves which are otherwise healthy, and they may be innocent or malignant.

The innocent forms are usually fibrous or myxomatous, and are definitely encapsulated. They may become cystic as a result of hæmorrhage or of myxomatous degeneration. They grow very slowly, are usually elliptical in shape, and the solid forms are rarely larger than a hazel nut. The nerve fibres may be spread out all round the tumour, or may run only on one side of it. When subcutaneous and related to the smaller unnamed cutaneous nerves, they are known as *painful subcutaneous nodules* or *tubercles*. These are chiefly met with in the lower extremities, and most often in women. They are remarkably sensitive, even gentle handling causing intense pain, which usually radiates to the periphery of the nerve affected. When related to deeper, named nerve-trunks, they are known as *trunk neuromata*. These are usually less sensitive than the "subcutaneous nodule," and they rarely give rise to motor symptoms unless when involving the nerve roots within the spinal canal.

These tumours are recognised clinically by their position in the line of a nerve, by the fact that they are movable in the transverse axis of the nerve but not in its long axis, and by their being painful and sensitive.

Treatment.—If they cause much suffering they should be removed, preferably by shelling them out from the investing nerve sheath or capsule. If the nerve is damaged, the portion to which the tumour is attached should be resected and the ends sutured. In the subcutaneous nodule the nerve is rarely recognisable, and is usually sacrificed.

The malignant neuroma is really a sarcoma growing from the sheath of a nerve. It has the same characters and clinical features as the innocent neuroma, only it grows more rapidly, and by destroying the nerve fibres causes motor symptoms—jerkings followed by paralysis. The sarcoma tends to spread along the lymphatic spaces of the affected nerve-trunk, as well as to implicate the surrounding tissues, and is liable to give rise to secondary growths. The malignant neuroma is met

with chiefly in the great sciatic and other large nerves of the limbs.

The best *treatment* is to amputate the limb well above the growth, as mere removal of the tumour is usually followed by recurrence. In incurable cases it may be possible to relieve pain by excising a portion of the nerve above the tumour, or, when this is impracticable, by resecting the posterior nerve roots and their ganglia within the spinal canal.

The so-called *amputation neuromata* have already been referred to (p. 352).

Diffuse or Generalised Neuro-Fibromatosis—Recklinghausen's Disease.—These terms are now used to include what were formerly known as "multiple neuromata," as well as certain other overgrowths related to nerves. The essential lesion is an overgrowth of the endoneural connective tissue throughout the nerves of both the cerebro-spinal and sympathetic systems.



FIG. 82.—Diffuse enlargement of Nerves in generalised Neuro-Fibromatosis.

(After R. W. Smith.)

The nerves are diffusely and unequally thickened, so that small twigs may become enlarged to the size of the median, while at irregular intervals along their course the connective-tissue overgrowth is exaggerated so as to form tumour-like swellings very similar to the trunk-neuromata already described. The tumours, which vary greatly in size and number—as many as a thousand have been counted in one case—are enclosed in a capsule derived from the nerve sheath. The fibromatosis may also affect the cranial nerves, the ganglia on the posterior nerve roots, the nerves within the spinal canal, and the sympathetic nerves and ganglia, as well as the continuations of the motor nerves within the muscles. The nerve fibres, although mechanically displaced and dissociated by the overgrown endoneurium, undergo no structural change.

The disease probably originates before birth, although it may not make its appearance till adolescence or even till adult life. It is sometimes met with in several members of one family.

It is recognised clinically by the presence of multiple tumours in the course of the nerves, and sometimes by palpable enlargement of the superficial nerve-trunks (Fig. 82). The tumours closely resemble the solitary trunk-neuroma, and they often remain quite insensitive. As a result of injury or other exciting cause, however, one or other tumour may increase in size and become extremely sensitive. The pain is much increased by handling, and may interfere with sleep. Motor disturbances are exceptional, unless in the case of tumours within the spinal canal, which may press on the cord and cause paraplegia. Neuro-fibromatosis is frequently accompanied by pigmentation of the skin in the form of brown spots or patches scattered over the trunk.

The disease is often stationary for long periods. In progressive cases the patient becomes exhausted, and usually dies of some intercurrent affection, particularly phthisis. The treatment is restricted to relieving symptoms and complications.

In a considerable proportion of cases one or other of the multiple tumours takes on the characters of a malignant growth ("secondary malignant neuroma," Garre). This malignant transformation may follow

upon injury, or on an attempt to remove the tumour. The features are those of a rapidly growing sarcoma involving a nerve-trunk, with agonising pain and muscular cramps, followed by paralysis from destruction of the nerve fibres. The removal of the tumour is usually followed by recurrence both in the nerve affected and in other nerves, so that high amputation is the only treatment to be recommended. Metastasis to internal organs is exceptional.

There are certain special types of neuro-fibromatosis which require brief mention.

The *plexiform neuroma* (Fig. 83) is a fibromatosis confined to



FIG. 83.—Plexiform Neuroma of small Sciatic Nerve, from a girl æt. 16.

(Mr. Annandale's case.)

the distribution of one or more contiguous nerves or of a plexus of nerves, and it may occur either by itself or along with a generalised neuro-fibromatosis. The clinical features are those of an ill-defined swelling composed of a number of tortuous, convoluted cords, lying in a loose areolar tissue and freely movable on one another. It is rarely the seat of pain or tenderness. It most often appears in the early years of life,

sometimes in relation to a pigmented or hairy mole. It is usually subcutaneous, and is frequently situated on the head or neck in the distribution of the trigeminal or superficial cervical nerves. The results of excision are satisfactory, even if the removal is not quite complete.

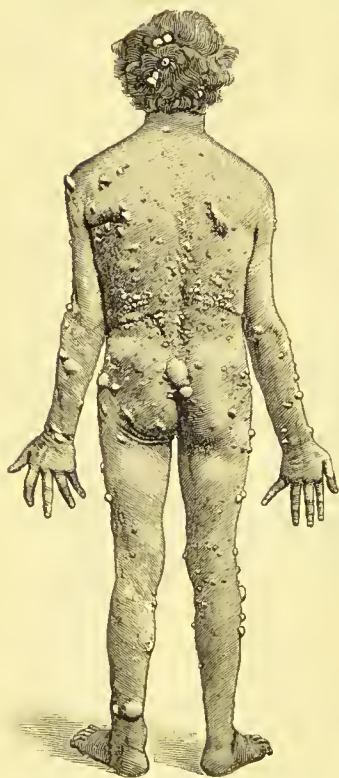


FIG. 84.—Multiple Neuro-Fibromata of Skin (*Molluscum fibrosum*).

(After von Recklinghausen.)

The *cutaneous neuro-fibroma* or *molluscum fibrosum* has been shown by von Recklinghausen to be a soft fibroma related to the terminal filaments of the cutaneous nerves (Fig. 84). The disease appears in the form of multiple, soft, projecting tumours of the skin, scattered all over the body, except the palms of the hands and soles of the feet, and frequently associated with pigmentation of the skin and with multiple tumours of the nerve-trunks. In exceptional cases one of the skin tumours may attain an enormous size and cause a hideous deformity, hanging down by its own weight in lobulated or folded masses (*pachydermatocoele*). These growths are very closely related to the plexiform

neuroma, and the skin over them may be pigmented and hairy. The treatment consists in removing the larger swellings; the small multiple tumours rarely call for interference.

Elephantiasis neuromatosa is the name applied by Virchow to a condition in which a limb is swollen and misshapen as a result of the extension of a neuro-fibromatosis to the skin and cellular tissue of the extremity as a whole (Fig. 85). While

it resembles other forms of elephantiasis, it usually begins in early life without apparent cause, and it may be associated with



FIG. 85.—Elephantiasis Neuromatosa in a woman æt. 28.

multiple tumours of the nerve-trunks. The inconvenience caused by the bulk and weight of the limb may justify its removal by amputation.

SURGERY OF THE INDIVIDUAL NERVES¹

The Brachial Plexus.—Lesions of the brachial plexus may be divided into those above the clavicle, which usually result from indirect violence, the force being applied to the head or shoulder; and those below the clavicle, which are usually caused by direct violence through the dislocated head of the humerus.

In the *supra-clavicular injuries*, the violence applied to the head or shoulder causes over-stretching of the anterior primary divisions of the cervical nerves, the fifth, or the fifth and sixth being those most liable to suffer in this way. Sometimes the traction is exerted upon the plexus from below, as when a man in falling from a height endeavours to save himself by clutching at some projection, and the injury mainly affects the first dorsal nerve. The lesion usually consists in a tearing of the nerve sheaths, with hæmorrhage, but in more severe cases partial or complete severance of nerve fibres may occur and these give way at different levels. During the healing process an excess of fibrous tissue is formed, which may seriously interfere with regeneration. *Post-æsthetic paralysis* occurs in patients in whom, during the course of an operation, the arms are abducted and rotated outwards or extended above the head, causing over-stretching of the plexus, especially of the fifth, or fifth and sixth, anterior primary divisions. A *cervical rib* may damage the plexus by direct pressure, the part usually affected being the inner cord, which is made up of fibres from the eighth cervical and first dorsal nerves. When a lesion of the brachial plexus complicates a *fracture of the clavicle*, the nerve injury is due, not to pressure on or laceration of the nerves by fragments of bone, but to the violence causing the fracture, and this is usually applied to the point of the shoulder. Penetrating *wounds* involving the plexus, apart from those met with in military practice, are rare.

In the *infra-clavicular injuries of the plexus*, the lesion most often results from the direct pressure of the dislocated head of the humerus; occasionally from attempts made to reduce the dislocation by the heel-in-the-axilla method, or from fracture of the upper end of the humerus or of the neck of the scapula. The whole plexus may suffer, but more frequently only the inner cord is implicated.

¹ We desire here to acknowledge our indebtedness to Mr. James Sherren's work on *Injuries of Nerves and their Treatment*. 1908.

Clinical Features.—Three types of lesion result from indirect violence: the whole plexus; the upper-arm type; and the lower-arm type.

When the whole plexus is involved, sensibility is lost over the entire forearm and hand and over the outer surface of the arm in its lower two-thirds. All the muscles of the arm, forearm, and hand are paralysed, and, as a rule, the pectorales and spinati, but the rhomboids and serratus magnus escape. There is paralysis of the sympathetic fibres to the eye and orbit, with narrowing of the palpebral fissure and recession of the globe, and the pupil is slow to dilate when shaded from the light.

The upper-arm type—Erb-Duchenne paralysis—is that most frequently met with, and it is due to a lesion of the fifth anterior primary division, or, it may be, also of the sixth. The position of the upper limb is typical: the arm and forearm hang close to the side, with the forearm extended and pronated; the deltoid, spinati, biceps, brachialis anticus, and supinators are paralysed, and in some cases the radial extensors of the wrist and the pronator radii teres are also affected. The patient is unable to supinate the forearm or to abduct the arm, and in most cases to flex the forearm. He may, however, regain some power of flexing the forearm when it is fully pronated, the extensors of the wrist becoming feeble flexors of the elbow. There is, as a rule, no loss of sensibility, but complaint may be made of tickling and of pins-and-needles over the outer side of the arm. The abnormal position of the limb may persist although the muscles regain the power of voluntary movement, and as the condition frequently follows a fall on the shoulder, great care is necessary in diagnosis, as the condition is apt to be attributed to an injury to the circumflex nerve.

The lower-arm type of paralysis, associated with the name of Klumpke, is usually due to over-stretching of the plexus, and especially affects the anterior primary division of the first dorsal nerve. In typical cases all the intrinsic muscles of the hand are affected, and the hand assumes the claw shape. Sensibility is usually altered over the inner side of the arm and forearm, and there is paralysis of the sympathetic.

Infra-clavicular injuries, as already stated, are most often produced by a sub-coracoid dislocation of the humerus; the inner cord is that most frequently injured, and the muscles paralysed are those supplied by the ulnar nerve, with, in addition, those intrinsic muscles of the hand supplied by the median. Sensibility is affected over the inner surface of the

forearm and ulnar area of the hand. Injury of the outer and posterior cords is very rare.

Treatment is carried out on the lines already laid down for nerve injuries in general. It is impossible to diagnose between complete and incomplete rupture of the nerve cords, until sufficient time has elapsed to allow of the establishment of the reaction of degeneration. If this is present at the end of fourteen days, operation should not be delayed. Access to the cords of the plexus is obtained by a dissection similar to that employed for the subclavian artery, and the nerves are sought for as they emerge from under cover of the scalenus anticus, and are then traced until the seat of injury is found. In the case of the first dorsal nerve, it may be necessary temporarily to resect the clavicle. The usual after-treatment must be persisted in until recovery ensues, and care must be taken that the paralysed muscles do not become over-stretched. The prognosis is less favourable in the supra-clavicular lesions than in those below the clavicle, which nearly always recover without surgical intervention.

In the *brachial birth-paralysis* met with in infants, the lesion is due to over-stretching of the plexus, and is nearly always of the Erb-Duchenne type. The injury is usually unilateral, it occurs with almost equal frequency in breech and in vertex presentations, and the left arm is more often affected than the right. The lesion is seldom recognised at birth. The first symptom noticed is tenderness in the supra-clavicular region, the child crying when this part is touched or the arm is moved. The attitude may be that of the Erb-Duchenne type, or the whole of the muscles of the upper limb may be flaccid, and the arm hangs powerless. A considerable proportion of the cases recover spontaneously. The upper arm is to be kept at rest, with the affected muscles relaxed, and, as soon as tenderness has disappeared, daily massage and passive movements are employed. The reaction of degeneration can rarely be satisfactorily tested before the child is three months old, but if it is present, an operation should be performed. After operation, the shoulder should be elevated so that no traction is exerted on the affected cords.

The nerve of Bell, which supplies the serratus magnus, is rarely injured. In those whose occupation entails carrying weights upon the shoulder it may be contused, and the resulting paralysis of the serratus is usually combined with paralysis of the lower part of the trapezius, the branches from the third and fourth cervical nerves which supply this muscle also being exposed

to pressure as they pass across the root of the neck. There is complaint of pain above the clavicle, and marked winging of the scapula; the patient is unable to raise the arm in front of the body above the level of the shoulder or to perform any forward pushing movements; on attempting either of these the winging of the scapula is at once increased. If the scapula is compared with that on the sound side, it is seen that, in addition to the lower angle being more prominent, the spine is more horizontal and the lower angle nearer the middle line. The majority of these cases recover if the limb is placed at absolute rest, the elbow supported, and massage and galvanism persevered with. If the paralysis persists, the sterno-costal portion of the pectoralis major may be transplanted to the lower angle of the scapula.

The nerve of Bell may be cut across while clearing out the axillary contents in the radical operation for cancer of the breast; the displacement of the scapula is not so marked as in the preceding type, and the patient is able to perform pushing movements below the level of the shoulder. If the reaction of degeneration develops, an operation may be performed, the ends of the nerve being sutured, or the distal end grafted into the posterior cord of the brachial plexus.

The Circumflex Nerve.—In the majority of cases in which paralysis of the deltoid follows upon an injury of the shoulder, it is due to a lesion of the fifth cervical nerve, as has already been described in injuries of the brachial plexus. The circumflex nerve itself as it passes round the neck of the humerus is most liable to be injured from the pressure of a crutch, or of the head of the humerus in sub-glenoid dislocations, or in fractures of the neck of the scapula or of the humerus. In miners, who work for long periods lying on the side, the muscle may be paralysed by direct pressure on the terminal filaments of the nerve, and the nerve may also be involved as a result of inflammation of the sub-deltoid bursa.

The deltoid is wasted, and the acromion unduly prominent. In recent cases the paralysis of the muscle is easily detected. In cases of long standing it is not so simple, because other muscles, the spinati, the clavicular fibres of the pectoral and the serratus, take its place and elevate the arm; there is always loss of sensation on the outer aspect of the shoulder. There is rarely any call for operative treatment, as the paralysis is usually compensated for by other muscles.

When the *supra-scapular nerve* is contused or stretched in injuries of the shoulder, the spinati muscles are paralysed

and wasted, the spine of the scapula is unduly prominent, and there is impairment in the power of abducting the arm and rotating it outwards.

The *musculo-cutaneous nerve* is very rarely injured; when cut across, there is paralysis of the coraco-brachialis, biceps and part of the brachialis anticus, but no movements are abolished, the forearm being flexed, in the pronated position, by the supinator longus and long radial extensor of the wrist; in the supinated position, by that portion of the brachialis anticus supplied by the musculo-spiral nerve. Supination is feebly performed by the supinator brevis. Protopathic and epieritic sensibility are lost over the radial side of the forearm.

Musculo-Spiral Nerve.—From its anatomical relationships this trunk is more exposed to injury than any other nerve in the body. It is frequently compressed against the humerus in sleeping with the arm resting on the back of a chair, especially in the deep sleep of alcoholic intoxication (drunkard's palsy). It may be pressed upon by a crutch in the axilla, by the dislocated head of the humerus, or by violent squeezing of the upper arm, as when an elastic tourniquet is applied too tightly. The most serious and permanent injuries of this nerve are associated with fractures of the humerus, especially those from direct violence attended with comminution. The nerve may be crushed or torn by one of the fragments at the time of the injury, or at a later period may be compressed by callus.

Clinical Features.—Immediately after the injury it is impossible to tell clinically whether the nerve is torn across or merely compressed. The patient may complain of numbness and tingling in the distribution of the radial nerve, but it is a striking fact, that so long as the nerve is divided below the level at which it gives off its external cutaneous branches, there is no loss of sensation. When it is divided above the origin of the external cutaneous branches, or when the posterior division of the musculo-cutaneous nerve is also divided, there is a loss of sensibility on the dorsum of the hand.

The motor symptoms predominate, the muscles affected being the extensors of the wrist and fingers, and the supinators. There is a characteristic "drop-wrist"; the wrist is flexed and pronated, and the patient is unable to dorsiflex the wrist or fingers (Fig. 86). If the hand and proximal phalanges are supported, the second and third phalanges may be partly extended by the interossei and lumbricals. There is also considerable impairment of power in the muscles which antagonise those that are paralysed, so that the grasp of the

hand is feeble, and the patient almost loses the use of it; in some cases this would appear to be due to the median nerve having been injured at the same time.

If the lesion is high up, as it is, for example, in crutch paralysis, the triceps and anconeus may also suffer.

Treatment.—The slighter forms of injury by compression recover under massage, douching, and electricity. If there is drop-wrist, the hand and forearm are placed on a palmar splint, with the hand dorsiflexed to nearly a right angle, and this position is maintained until the voluntary dorsiflexion at the wrist returns to the normal. Recovery is sometimes delayed for several months.

In the more severe injuries of the nerve associated with fracture of the humerus and attended with the reaction of degeneration, it is necessary to cut down upon the nerve and free it from the pressure of a fragment of bone or from callus or adhesions. If the nerve is torn across, the ends must be sutured, and if this is impossible owing to loss of tissue, the gap may be bridged by a graft taken from the radial nerve, or the ends



FIG. 86.—Drop-Wrist from Musculo-Spiral Paralysis, the result of wound of upper arm.

may be implanted into the median, an incision being made through the sheath of this nerve at each point of implantation.

Finally, in cases in which the paralysis is permanent and incurable, the disability may be relieved by grafting the flexor carpi ulnaris into the common extensor of the fingers. Similarly the flexor carpi radialis may be grafted into the tendon of the extensor longus pollicis. The extensors of the wrist may be shortened, so as to place the hand in the position of dorsal flexion, and thus improve the attitude and grasp of the hand.

The radial and posterior interosseous nerves, apart from being involved in lesions of the musculo-spiral, are liable to be contused or torn in dislocations of the head of the radius, and in fracture of the neck of the bone. The

posterior interosseous may be divided as it passes through the supinator brevis in operations on old fractures and dislocations in the region of the elbow. Division of the radial nerve in the upper two-thirds of the forearm produces no loss of sensibility; division in the lower third after the nerve has become associated with branches from the musculo-cutaneous is followed by a loss of sensibility on the radial side of the hand and thumb. Wounds of the dorsal surface of the wrist and forearm are often followed by loss of sensi-

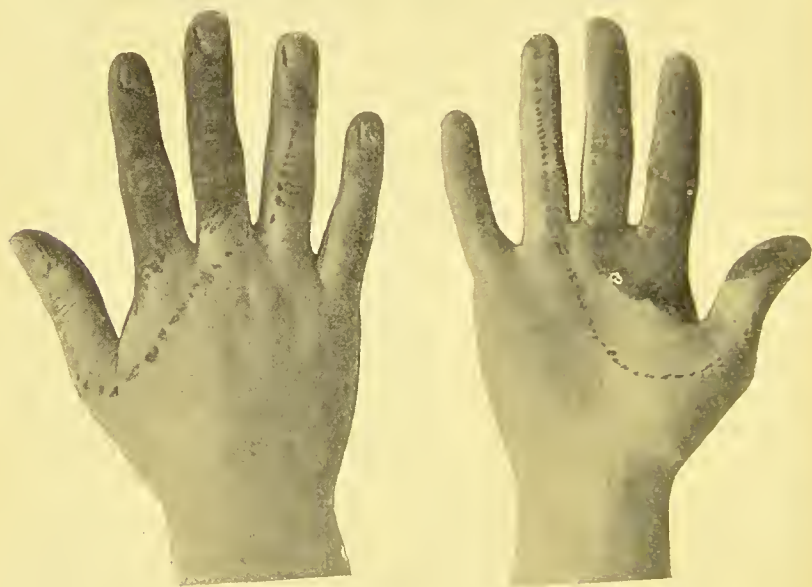


FIG. 87.—To illustrate the Loss of Sensation produced by Division of the Median Nerve. The area of complete cutaneous insensibility is shaded black. The parts insensitive to light touch and to intermediate degrees of temperature are enclosed within the dotted line. (After Head and Sherren.)

bility over a larger area, because the musculo-cutaneous nerve is divided as well, and some of the fibres of the lower external cutaneous branch of the musculo-spiral.

The median nerve is most frequently injured in wounds in the region of the wrist made by broken glass. It may also be injured in fractures of the lower end of the humerus, in fractures of both bones of the forearm, and as a result of pressure by splints. After *division at the elbow*, there is impairment of mobility which affects chiefly the thumb, and to a less extent the index finger: the terminal phalanx of

the thumb cannot be flexed owing to the paralysis of the flexor longus pollicis, and the index can only be flexed at its metacarpo-phalangeal joint by the interosseous muscles attached to it. Pronation of the forearm is feeble, and is completed by the weight of the hand. After *division at the wrist*, the abductor-opponens group of muscles and the outer two lumbricals only are affected; the abduction of the thumb can be feebly imitated by the extensor brevis and the extensor ossis metacarpi pollicis, while opposition may be simulated by contraction of the long flexor and the abductor of the thumb; the paralysis of the outer two lumbricals produces no symptoms that can be recognised. It is important to remember that when the median nerve is divided at the wrist, deep touch can be appreciated over the whole of the area supplied by the nerve; the injury, therefore, is very liable to be overlooked. If, however, the tendons are divided as well



FIG. 88.—Claw-hand following Division of Ulnar Nerve above Wrist.

as the nerve, there is insensibility to deep touch. The areas of epicritic and of protopathic insensibility are illustrated in Fig. 87. The division of the nerve at the elbow, or even at the axilla, does not increase the extent of the loss of epicritic or protopathic sensibility, but usually affects deep sensibility.

The Ulnar Nerve.—The most common injury of this nerve is its division in transverse accidental wounds just above the wrist. In the upper arm it may be contused, along with the musculo-spiral, in crutch paralysis; in the region of the elbow it may be injured in fractures or dislocations, or it may be accidentally divided in the operation for excising the elbow-joint.

When it is injured *at or above the elbow*, there is paralysis of the flexor carpi ulnaris, the ulnar half of the flexor profundus digitorum, all the interossei, the two inner lumbricals, and the adductors of the thumb. The hand assumes a

characteristic attitude: the index and middle fingers are extended at the metacarpo-phalangeal joints owing to paralysis of the interosseous muscles attached to them; the little and ring fingers are hyper-extended at these joints in consequence of the paralysis of the lumbricals; all the fingers are flexed at the inter-phalangeal joints, the flexion being most marked in the little and ring fingers—claw-hand or *main en griffe* (Fig. 88). On flexing the wrist, the hand is slightly tilted to the radial side, but the paralysis of the flexor carpi ulnaris is often compensated for by the action of the palmaris longus. The little and ring fingers can be flexed to a slight degree by the slips of the flexor sublimis attached to them and supplied by the median nerve; flexion of the terminal phalanx of the little finger is almost impossible. Abduction and adduction movements of the fingers are lost. Adduction of the thumb is carried out, not by the paralysed adductor pollicis, but the movement may be simulated by the long flexor and extensor muscles of the thumb. Epicritic sensibility is lost over the little finger, the ulnar half of the ring finger, and that part of the palm and dorsum of the hand to the ulnar side of a line drawn longitudinally through the ring finger and continued upwards. Protopathic sensibility is lost over an area which varies in different cases. Deep sensibility is usually lost over an area almost as extensive as that of protopathic insensibility.

When the nerve is *divided at the wrist*, there is often division of adjacent tendons also. If divided below the point at which its dorsal branch is given off, the sensory paralysis is much less marked, and the injury is therefore liable to be overlooked until the wasting of muscles and typical *main en griffe* ensue. The loss of sensibility after division of the nerve before the dorsal branch is given off, resembles that after division at the elbow, except that in uncomplicated cases deep sensibility is usually retained. If the tendons are divided as well, however, deep touch may also be lost.

Special care must be taken in all these injuries to prevent deformity; a splint must be worn, at least during the night, until the muscles regain their power of voluntary movement, and then exercises should be instituted.

Dislocation of the ulnar nerve at the elbow may result from sudden and violent flexion of the joint, the muscular effort causing stretching or laceration of the fascia that holds the nerve in its groove; it is predisposed to if the groove is

shallow as a result of imperfect development of the internal condyle of the humerus, and by eubitus valgus.

The nerve slips forward, and may be felt lying on the inner aspect of the condyle. It may retain this position, or it may slip backwards and forwards with the movements of the arm. The symptoms at the time of the displacement are a certain amount of disability at the elbow, and pain and tingling along the nerve, which are exaggerated by movement and by pressure.



FIG. 89.—To illustrate Loss of Sensation produced by complete Division of Ulnar Nerve. Loss of all forms of cutaneous sensibility is represented by the shaded area. The parts insensitive to light touch and to intermediate degrees of heat and cold are enclosed within the dotted line. (Head and Sherren.)

The symptoms may subside altogether, or a neuritis may develop, with severe pain shooting up the nerve.

The dislocated nerve is easily replaced, but is difficult to retain in position. In recent cases the arm may be placed in the extended position with a pad over the condyle, care being taken to avoid pressure on the nerve. Failing relief, it is better to make a bed for the nerve by dividing the deep fascia behind the internal condyle and to stitch the edges of the fascia over the nerve. This operation has been successful in all the recorded cases.

The external popliteal nerve is most exposed to injury where

it winds round the neck of the fibula. It may be compressed by a tight bandage or tourniquet, or it may be bruised or torn in fractures of the upper end of the bone. It has been divided in accidental wounds—by a scythe, for example—and in performing subcutaneous tenotomy of the biceps tendon. Cases have been observed of paralysis of the nerve as a result of prolonged acute flexion of the knee in certain occupations.

When the nerve is paralysed, the most obvious result is “drop-foot”; the patient is unable to dorsiflex the foot and cannot lift his toes off the ground, so that in walking he is obliged to throw or jerk the foot forwards and outwards. There is loss of protopathic and epicritic sensibility over the dorsum of the foot, but deep sensibility is not affected. In course of time the foot becomes markedly inverted and the toes are pointed—*pes equino-varus*—and trophic sores are liable to form.

The internal popliteal nerve is rarely injured.

The sciatic nerve also is little exposed to injury. When it is compressed, as by sitting on a fence, there is tingling and powerlessness in the limb as a whole, known as “sleeping” of the limb, but these phenomena are usually evanescent. The nerve is frequently injured in gun-shot wounds. The limb is at first quite powerless, but the patient usually recovers sufficiently to be able to walk without a support. Although the hamstrings are paralysed, the knee can be flexed by the sartorius and gracilis. The external popliteal portion suffers most, and the chief clinical feature is drop-foot. The foot is usually cold and bluish, and may present trophic sores. There is loss of sensibility below the knee except in the distribution of the long saphenous nerve, on the inner aspect of the lower half of the leg and inner side of the foot; deep touch is affected only over a comparatively small area of the foot.

The cranial nerves are considered with affections of the head and neck (vol. ii. chap. iv.).

NEURALGIA

The term neuralgia is applied clinically to any pain which follows the course of a particular nerve and its branches, and is not referable to any discoverable cause. This term should not be applied to pain which results from pressure on a nerve by a tumour, a mass of callus, an aneurysm, or

by any similar gross lesion. We shall only consider here those forms of neuralgia which are amenable to surgical treatment.

Brachial Neuralgia.—One or more of the roots or branches of the brachial plexus may be the seat of pain. The pain is definitely located in the distribution of one of the branches or nerve roots, is often intermittent, and is usually associated with tingling and disturbance of tactile sensation. It may be due to a localised neuritis, or no cause may be discoverable. The region of the root of the neck should be carefully examined to exclude pressure by a cervical rib, a tumour, or an aneurysm as the cause of the pain. When medical treatment fails, recourse may be had to operative measures, the affected cords being exposed and stretched through an incision in the posterior triangle of the neck. If this fails to give relief, the more serious operation of resecting the posterior roots of the affected nerves within the spinal canal may be considered.

Neuralgia of the great sciatic nerve—**sciatica**—is the most common form of neuralgia met with in surgical practice.

A definite cause of the pain is rarely ascertainable. The condition is chiefly met with in adults of gouty or rheumatic tendencies who suffer from indigestion, constipation, and oxaluria—in fact, the same type of patients who are liable to lumbago, and the two affections are frequently associated in the same person. In hospital practice it is commonly met with in coal-miners and others who assume a squatting position at work. The actual onset of the pain may follow over-exertion and exposure to cold and wet, especially in those who do not take regular exercise. Any error of diet or indulgence in beer or wine may contribute to its development.

The essential symptom is paroxysmal or continuous pain along the course of the nerve in the buttock, thigh, or leg. It may be comparatively slight, or it may be so severe as to prevent sleep. It is usually aggravated by movement, so that the patient walks lame or is obliged to lie up. It is aggravated also by any movement which tends to put the nerve on the stretch, as in bending down to put on the shoes, such movements also causing tingling down the nerve, and sometimes numbness in the foot. This may be demonstrated by flexing the thigh on the abdomen, the knee being kept extended. There is no pain if the same manœuvre is repeated with the knee flexed. The nerve is sensitive to pressure, the most tender points being its emergence from the sacro-sciatic foramen, the hollow between the trochanter and the ischial tuberosity, and where the external popliteal

nerve winds round the neck of the fibula. The muscles of the thigh are often wasted and weak.

The clinical features vary a good deal in different cases; the affection is often obstinate, and may last for many weeks or even months.

In the sciatica that results from neuritis, there may be patches of cutaneous anæsthesia, loss of tendon reflexes, localised wasting of muscles, and vaso-motor and trophic changes. The presence of the reaction of degeneration confirms the diagnosis of neuritis. A diminution in the surface temperature of the limb is held by some to be pathognomonic. In long-standing cases the pain and discomfort may lead to a postural scoliosis (*ischias-scoliotica*).

Diagnosis.—Pain referred along the course of the sciatic nerve is a common symptom of tumours of the uterus, the rectum, or the pelvic bones. It may result also from the pressure of an abscess or an aneurysm either inside the pelvis or in the buttock, and is sometimes associated with organic disease of the spinal cord, such as tabes. Sciatica may also be mistaken for disease in the hip or sacro-iliac joint, especially tuberculous disease and arthritis deformans. It is necessary, therefore, to exclude such conditions before arriving at a diagnosis of sciatica. A digital examination of the rectum or vagina is of great value in excluding intra-pelvic tumours.

Treatment is both general and local. Any constitutional tendency, such as gout or rheumatism, must be counteracted, and indigestion, oxaluria, and constipation must receive appropriate treatment. In acute cases the patient is confined to bed, the limb is wrapped up in wool, and the knee is flexed over a pillow. A rubber hot-bottle may be applied over the seat of greatest pain. The bowels should be well opened by castor oil or by calomel followed by a saline. Salicylate of soda in full doses, or aspirin, usually proves effectual in relieving pain, but when this is very intense it may call for injections of heroin or morphin. Benefit has followed the injection into the nerve itself, or into the tissues surrounding it, of normal saline solution; from 70–100 c.c. are injected at one time. If the pain recurs, a second injection is usually followed by its complete disappearance.

In the less severe cases the patient should be encouraged to move about and take regular exercise. Marked relief usually results from bathing, douching, and massage, and from repeated gentle stretching of the nerve. This may be carried out by passive movements of the limb—the hip being flexed while the

knee is kept extended ; and by active movements—the patient flexing the limb at the hip, the knee being maintained in the extended position. These exercises, which may be preceded by massage, are carried out night and morning, and should be practised systematically by those who are liable to sciatica.

In obstinate and severe cases the *nerve may be needled*, or it may be *forcibly stretched*. Needling or acupuncture of the sciatic consists in piercing the nerve at intervals in the buttock and thigh with long steel needles. Six or eight needles are inserted and left in position for from fifteen to thirty minutes. The nerve may be stretched under anæsthesia by placing the patient on his back with the hip flexed to a right angle, and then gradually extending the knee until it is in a straight line with the thigh (Billroth). A more effectual method is to expose the nerve through an incision at the fold of the buttock, and forcibly pull upon it. This operation is most successful when the pain is due to the nerve being involved in adhesions (Crawford Renton). The general regimen already described is also carried out during the after-treatment.

Trigeminal Neuralgia.—A severe form of epileptiform neuralgia occurs in one or more branches of the fifth nerve, and is one of the most painful affections with which we have to deal. So far as its pathology is known, it is believed to be associated with degenerative changes in the Gasserian ganglion. It is met with in adults, and develops without apparent cause ; it is almost invariably unilateral. The pain, which occurs in paroxysms, is at first of moderate severity, but gradually becomes agonising. In the early stages the paroxysms occur at wide intervals, but later they recur with such frequency as to be almost continuous. They are usually excited by some trivial cause, such as opening the jaws in eating or speaking, touching the face as in washing, or by exposure to a draught of cold air. Between the paroxysms the patient is free from pain, but is in constant terror of its return, and the face wears an expression of extreme suffering and anxiety. When the paroxysm is accompanied by twitching of the facial muscles, it is called *spasmodic tic*.

The skin of the affected area may be glazed and red, or may be pale and moist with inspissated sweat, the patient not daring to touch it.

There is excessive tenderness at the points of emergence of the different branches of the fifth nerve on the face, and pressure over one or other of these points may excite a paroxysm of pain. In typical cases the patient is unable to take any

active part in life. The attempt to eat is attended with such severe pain that he avoids taking food. In some cases the suffering is so great that the patient only obtains sleep by the use of hypnotics, and he is often on the verge of committing suicide.

Diagnosis.—There is seldom any difficulty in recognising the disease. It is important, however, to exclude the hysterical form of neuralgia, which is characterised by its occurrence earlier in life, by the pain varying in situation, being frequently bilateral, and being more often constant than paroxysmal.

Treatment.—Before having recourse to the measures described below, it is advisable to give a thorough trial to such drugs as arsenic, quinine, and strychnin, and to employ the other medical measures used in the treatment of neuralgia.

The Injection of Alcohol into the Nerve.—The alcohol acts by destroying the nerve fibres, and must be brought into direct contact with them; if the nerve has been properly struck the injection is followed by complete anæsthesia in the distribution of the nerve. The relief may last for from six months to three years; if the pain returns, the injection may be repeated. The strength of the alcohol should be 85 per cent., and the amount injected about 2 c.c.; a general, or preferably a local, anæsthetic should be employed (Schlösser).

Operative Treatment.—This consists in the removal of the affected nerve or nerves as completely as possible, either by resection—*neurectomy*; or by a combination of resection with twisting or tearing of the nerve from its central connections—*avulsion*. To prevent the regeneration of the nerve after these operations, the canal of exit through the bone should be obliterated; this is best accomplished by a silver screw-nail driven home by an ordinary screw-driver (Charles H. Mayo).

When the neuralgia involves branches of two or of all three divisions, or when it has recurred after temporary relief following resection of individual branches, the *removal of the Gasserian ganglion*, along with the main trunks of the second and third divisions, should be considered. This is usually carried out by what is known as the Krause-Hartley operation, which consists in making a large opening into the skull in the temporal region, stripping up the dura, and raising the temporo-sphenoidal lobe of the brain from the middle fossa of the skull until the ganglion is exposed lying on the upper aspect of the petrous temporal bone.

The operation is a difficult and serious one, but the results

are satisfactory so far as the cure of the neuralgia is concerned. There is little or no disability from the unilateral paralysis of the muscles of mastication; but on account of the insensitiveness of the cornea, the eye must be protected from irritation, especially during the first month or two after the operation; this may be done by fixing a large watch-glass around the edge of the orbit with adhesive plaster.

If the first division of the fifth nerve is not involved, neither it nor the ganglion should be interfered with; the second and third divisions should be divided within the skull, and the foramen rotundum and foramen ovale plugged with rubber made soft by heat, or a thin plate of lead or silver is fitted so as to cover both openings.

CHAPTER XVII

THE SKIN AND SUBCUTANEOUS TISSUE

Structure of skin — *Blisters* — *Callosities* — *Corns* — *Chilblains* — *Boils* — *Carbuncle* — *Abscess* — *Veldt sores* — Tuberculosis of skin : *Inoculation tubercle* — *Lupus* : *Varieties* — Elephantiasis : *Varieties* — Sebaceous cysts or wens — Moles — Horns — New growths : *Fibroma* ; *Papilloma* ; *Adenoma* ; *Epithelioma* ; *Rodent cancer* ; *Melanotic cancer* ; *Sarcoma* — AFFECTIONS OF CICATRICES — *Varieties of scars* — *Keloid* — *Tumours* — AFFECTIONS OF NAILS.

Structure of Skin.—The skin is composed of a superficial cellular layer—the epidermis, and the corium or true skin. The *epidermis* is differentiated from without inwards into the stratum corneum, the stratum lucidum, the stratum granulosum, and the rete Malpighii or germinal layer, from which all the others are developed. The *corium* or *true skin* consists of connective tissue, in which ramify the blood-vessels, lymphatics, and nerves. That part of the corium immediately adjoining the epidermis is known as the papillary portion, and contains the terminal loops of the cutaneous blood-vessels and the terminations of the cutaneous nerves. The deeper portion of the true skin is known as the reticular portion, and is largely composed of adipose tissue.

Blisters result from the exudation and accumulation of serous fluid beneath the horny layer of the epidermis. The fluid may be clear, as in the blisters of a recent burn, or blood-stained, as in the blisters so commonly seen accompanying severe fractures of the leg. It may become purulent as a result of infection, and this may be the starting-point of lymphangitis, cellulitis, or lymphadenitis.

The skin should be disinfected and the blisters punctured. When septic, the separated horny layer must be cut away with seissors to allow of the necessary disinfection.

Callosities are prominent, indurated masses of the overgrown horny layer of the epidermis, where it has been exposed to prolonged friction and pressure. They occur on the fingers and hand as a result of certain occupations and sports, but are most common under the balls of the toes or heel. A bursa may form beneath a callosity, and if it becomes inflamed may cause

considerable suffering; if suppuration ensues, a sinus may form, resembling a perforating ulcer of the foot.

The *treatment* of callosities on the foot consists in removing pressure by wearing properly fitting boots, and in applying a ring pad around the callosity; another method is to fit a sock of spongiopilene with a hole cut out opposite the callosity. After soaking in hot water, the overgrown horny layer may be pared away with a knife, and the part painted once daily with a saturated solution of salicylic acid in flexile collodion.

Corns.—A corn is a localised overgrowth of the horny layer of the epidermis, which grows downwards, pressing upon and displacing the sensitive papillæ of the corium. Corns are due to the friction and pressure of ill-fitting boots, and are met with chiefly on the toes and sole of the foot. A corn is usually hard, dry, and white; but it may be sodden from moisture, as in “soft corns” between the toes. A bursa may form beneath a corn, and if inflamed constitutes one form of bunion. When suppuration takes place in relation to a corn, there is great pain and disability, and it may prove the starting-point of lymphangitis.

The *treatment* consists in the wearing of properly fitting boots and stockings, and, if the symptoms persist, the corn should be removed. This is done after the manner of chiropodists by digging out the corn with a suitably shaped knife. A more radical procedure is to excise, under local anæsthesia, the portion of skin containing the corn and the underlying bursa if present. The majority of so-called corn solvents consist of a solution of salicylic acid in collodion; if this is painted on daily, the epidermis dies and is thus more easily pared away. The unskilful paring of corns on the toes may determine the occurrence of senile gangrene in those who are predisposed to this disease by atheromatous arteries.

Chilblains.—Chilblain or *erythema pernio* is a vascular disturbance resulting from the alternate action of cold and heat on the distal parts of the body. Chilblains are met with chiefly on the fingers and toes in children and anæmic girls. In the mild form there is a sensation of burning and itching, the part becomes swollen, of a dusky-red colour, and the skin tense and shiny. In more severe cases the burning and itching are attended with pain, and the skin becomes of a violet or wine-red colour. There is a third degree, closely approaching frost-bite, in which the skin tends to blister and give way, leaving an indolent raw surface popularly known as a “broken chilblain.”

Those liable to chilblains should take open-air exercise, nourishing food, cod-liver oil, and tonics. Woollen stockings and gloves should be worn in cold weather, and sudden changes of temperature avoided. The symptoms may be relieved by ichthyol ointment, glycerin and belladonna, or a mixture of Venice turpentine, castor oil, and collodion applied on lint which is wrapped round the toe. Balsam of Peru or resin ointment spread on muslin should be applied to broken chilblains. The most effective treatment is Bier's bandage applied for about six hours twice daily; it can be worn while the patient is following his occupation; in chronic cases this may be supplemented with the hot-air bath.

Boils and Carbuncles.—These result from infection with the staphylococcus aureus, which enters the orifices of the ducts of the skin under the influence of friction and pressure, as was demonstrated by the well-known experiment of Garré, who produced a crop of pustules and boils on his own forearm by rubbing in a culture of the staphylococcus aureus.

A **Boil** results when the infection is located in a hair follicle or sebaceous gland. A hard, painful, conical swelling develops, to which, so long as the skin retains its normal appearance, the term "blind boil" is applied. Usually, however, the skin becomes red, and after a time breaks, giving exit to a drop or two of thick pus. After an interval of from six to ten days a soft white slough is discharged; this is known as the "core," and consists of the necrosed hair follicle or sebaceous gland. After the separation of the core the boil heals rapidly, leaving a small depressed scar.

Boils are most frequently met with on the back of the neck and the buttocks, and on other parts where the skin is coarse and thick and is exposed to friction and pressure. The occurrence of a number or a succession of boils is due to spread of the original infection, the cocci from the original boil infecting adjacent hair follicles. The spread of boils may be unwittingly promoted by the use of a domestic poultice or the wearing of infected underclothing.

While boils are frequently met with in debilitated persons, and particularly in those suffering from diabetes or Bright's disease, they also occur in those who enjoy vigorous health. They seldom prove dangerous to life except in diabetic subjects, but when they occur on the face there is a risk of lymphatic and of general pyogenic infection. Boils may be differentiated from syphilitic lesions of the skin by their acute onset and progress, and by the absence of other evidence of syphilis; and

from the malignant or anthrax pustule by the absence of the central black slough and of the circumstances which usually favour anthrax infection.

Treatment.—The skin of the affected area should be painted with iodine, and a Klapp's suction bell applied thrice daily. If pus forms, the skin is frozen with ethyl-chloride and a small incision made, after which the application of the suction bell is persevered with. The further treatment consists in the use of diluted boracic or resin ointment. In multiple boils on the trunk and limbs, lysol or boracic baths are of great service; the underclothing should be frequently changed, and that which is discarded must be disinfected.

Any impaired condition of health should be corrected; when there is sugar or albumen in the urine the conditions on which these depend must receive appropriate treatment. When there are successive crops of boils, recourse should be had to the vaccine treatment; a stock vaccine of the staphylococcus aureus containing 600 millions of dead cocci in each cubic centimetre is employed, a half cubic centimetre being injected at intervals of four days.

Carbuncle may be looked upon as an aggregation of boils, and is characterised by a densely hard base and a brownish-red discoloration of the skin. A carbuncle is usually about the size of a crown-piece, but it may continue to enlarge until it attains the size of a dinner-plate. The patient is ill and feverish, and the pain may be so severe as to prevent sleep. As time goes on several points of suppuration appear, and when these burst there are formed a number of openings in the skin, giving it a cribriform appearance; these openings exude pus. The different openings ultimately fuse and the large adherent greyish-white slough is exposed. The separation of the slough is a tedious process, and the patient may become exhausted by pain, discharge, and septic absorption. When the slough is finally thrown off, a deep gap is left, which takes a long time to heal. A large carbuncle is a grave disease, especially in a weakly person suffering from diabetes or chronic alcoholism. In the majority of cases the patient is laid aside for several months. It is most common in male adults over forty years of age, and is usually situated on the back between the shoulders. When it occurs on the face or anterior part of the neck it is especially dangerous, because of the greater risk of general infection.

A carbuncle is to be differentiated from an ulcerated syphilitic gumma and from anthrax pustule.

Treatment.—Pain is to be relieved by full doses of opium or codein, and these drugs are specially indicated when sugar is present in the urine. The diet should be liberal and easily digested, and alcoholic and other stimulants may be of service in tiding the patient over the critical period of the disease. Locally the treatment is carried out on the same lines as for boils.

In some cases it may be advisable to excise the carbuncle or to make incisions across it in different directions, so that the resulting wound presents a stellate appearance.

Acute Abscesses of the Skin and Subcutaneous Tissue in Young Children.—In young infants, abscesses are not infrequently met with scattered over the trunk and limbs, and are probably the result of infection of the sebaceous glands from dirty underclothing. The abscesses should be opened, and the further spread of infection prevented by thorough cleansing of the skin and by the use of clean under-linen. Similar abscesses are met with on the scalp in association with eczema, impetigo, and pediculosis.

Veldt Sore.—The sore usually originates in an abrasion of the epidermis, such as a sun blister, the bite of an insect, or a small wound or scratch. A pustule forms and bursts, and a brownish-yellow scab forms over it. When this is removed, a raw surface or ulcer is left which has little tendency to heal. These sores are most common about the hands, arms, neck, and feet, and are most apt to occur in those who have had no opportunities of washing, and who have lived for a long time on tinned foods. The appearance of a number of white scars, each surrounded by a zone of pigmentation, similar to but smaller than those resulting from syphilis, is commonly observed in those who have suffered from veldt sores.

Tuberculosis of the Skin.—Interest attaches chiefly to the primary forms of tuberculosis of the skin in which the bacilli usually penetrate from without—inoculation tubercle and lupus.

Inoculation Tubercle.—The appearances vary with the conditions under which the inoculation takes place. As observed on the fingers of adults, the affection takes the form of an indolent, painless swelling, the epidermis being red and glazed, or warty and irregularly fissured. Sometimes the epidermis gives way, forming an ulcer with flabby granulations. The infection rarely spreads to the lymphatics.

In children who run about barefooted in towns, tubercle may be inoculated into accidental wounds in the sole or about

the toes, and although the local appearances may not be characteristic, the nature of the infection is revealed by its tendency to spread up the limb along the lymphatic vessels, giving rise to enlargement, abscesses, and fungating ulcers in relation to the femoral glands.

Tuberculous Lupus.—This is an extremely chronic affection of the skin. It rarely extends to the lymphatic glands, and of all tuberculous lesions is the least dangerous to life. The commonest form of lupus—*lupus vulgaris*—usually commences in childhood or youth, and is most often met with on the nose or cheek. The early and typical appearance is that of brownish-yellow or pink nodules in the skin, about the size of hemp seed. Their characters are best studied by examining them through a lens pressed firmly against the skin. The appearance of the contents of these nodules has been likened to apple jelly. Microscopical examination shows the apple-jelly material to consist of aggregations of epithelioid and giant cells over which the epidermis is stretched and thinned. Tubercle bacilli are scanty and difficult to stain. The original nodules tend to fuse together, while fresh ones are formed at the margins. “The epidermis, as a result of surface irritation in which pus organisms play a prominent part, becomes the seat of a catarrhal process attended with a discharge of pus which dries up, forming yellowish-brown crusts or scabs, and the apple-jelly nodules are thereby concealed; when the scabs are removed, what looks like a raw surface covered with pale granulation tissue is exposed” (Norman Walker). Healing frequently occurs in the centre of the affected area while the disease continues to extend at the margins.

When there is actual destruction of tissue and ulceration—the so-called “*lupus excedens*” or “*ulcerans*”—healing is attended with cicatricial contraction, which may cause unsightly deformity. When the cheek is affected, the lower eyelid may be drawn down and everted; when the lips are affected, the mouth may be distorted or seriously diminished in size. When the nose is affected, both the skin and mucous surfaces are usually involved, and the nasal orifices may be narrowed or even obliterated; sometimes the soft parts, including the cartilages, are destroyed, leaving only the bones covered by tightly stretched scar tissue.

The disease progresses very slowly, healing in some places and spreading at others. The patient complains of a burning sensation, but very little of pain, and is chiefly concerned about the disfigurement. Nothing is more characteristic of

lupus than the appearance of fresh nodules in parts which have already healed. In the course of years large tracts of the face and neck may become affected. From the lips it may spread to the gum and palate, giving to the mucous membrane the appearance of a raised, bright-red, papillary or villous surface. When the disease affects the gums, the teeth may become loose and fall out.

On parts of the body other than the face, the disease is even more chronic, and is often attended with a considerable production of dense fibrous tissue—the so-called *fibroid lupus*; there are very few tubercle nodules, and the disease has little tendency to destroy parts. Sometimes there is a warty thickening of the epidermis—*lupus verrucosus*. In the fingers and toes it may lead to a progressive destruction of tissue like that observed in certain forms of leprosy, and from the resulting loss of portions of the digits it has been called *lupus mutilans*. In the lower extremity a remarkable form of the disease is sometimes met with, to which the term *lupus elephantiasis* has been applied. It usually commences as an ordinary lupus of the toes or dorsum of the foot, from which the tuberculous infection spreads to the lymphatic vessels, and the limb as a whole becomes enormously swollen and unshapely (Fig. 91).

Finally, a long-standing lupus, especially on the cheek, may become the seat of epithelioma—*lupus epithelioma*—usually of the exuberant or cauliflower type, which presents little tendency to infect the lymphatics.

The *diagnosis* of lupus is founded on the chronic progress and long duration, on the recognition of the apple-jelly nodules, and the central scarring with peripheral extension of the disease. On the face it is most liable to be confused with syphilis and with rodent cancer. The syphilitic lesion belongs to the tertiary period, and although presenting a superficial resemblance to tuberculosis, its progress is much more rapid, so that within a few months it may involve an area of skin as wide as would be affected by lupus in as many years. Further, it readily yields to anti-syphilitic treatment. In cases of tertiary syphilis in which the nose is destroyed, it will be noticed that the bones have suffered most, while in lupus the destruction of tissue involves chiefly the soft parts of the tip of the nose.

Rodent cancer is liable to be mistaken for lupus, because it may affect the same parts of the face; it is equally chronic, and may partially heal. It begins later in life, however, the

margin of the ulcer is more sharply defined, and often presents a "rolled" appearance.

Numerous methods are employed for the *treatment* of lupus. When the disease is confined to a very limited area, the most rapid and certain cure is obtained by *excision*. The whole thickness of skin is removed throughout and beyond the area affected; the edges of the gap are brought together by sutures, or the raw surface is covered with a Thiersch graft. On the covered parts of the body excision may be employed, even when the disease involves an extensive area.

When lupus covers a wide area of the face, as is more often the case in hospital practice, there is great difficulty in bringing about a cure. In recent years the therapeutic effects obtained by exposure to different forms of rays have been so satisfactory that they have superseded the older methods. The *ray treatment* includes the use of luminous, Röntgen, or other rays, and possesses the advantage of being comparatively painless and of being followed by the least amount of scarring and deformity.

The Röntgen-ray treatment consists in exposing the diseased area to the rays from a Crookes' tube of about six-inches spark, for ten or fifteen minutes daily, at a distance of from four to five inches from the tube. The healthy skin is protected by a sheet of lead foil, from which a piece is cut out corresponding to the diseased area. After a variable number of exposures, inflammatory reaction takes place, and experience is required to control the effects within the desired limits.

The rays given off from radium have been found to have a similar curative influence on tuberculous lesions of the skin.

Encouraging results have also been obtained by the application of carbon dioxide snow.

Multiple subcutaneous tuberculous nodules are met with chiefly on the extremities of children. They are indolent and painless, and rarely attract attention until they break down and form abscesses, which are usually about the size of a cherry, and when these burst sinuses or ulcers result. If the overlying skin is still intact, the best treatment is to excise the abscess. If the abscess has already infected the skin, each focus should be scraped and packed with gauze.

Elephantiasis.—This term is applied to an excessive enlargement of a part depending upon an overgrowth of the skin and subcutaneous cellular tissue, and it may result from a number of causes, acting independently or in combination. The condition

is observed chiefly in the extremities and in the external organs of generation.

Elephantiasis from Lymphatic or Venous Obstruction.—Of this the best-known example is *tropical elephantiasis* (*E. arabum*), which is endemic in Samoa, Barbadoes, and certain other places. It attacks the lower extremity or the genitals in either sex (Fig. 90). The disease is usually ushered in with fever, and signs of lymphangitis in the part affected. After a num-

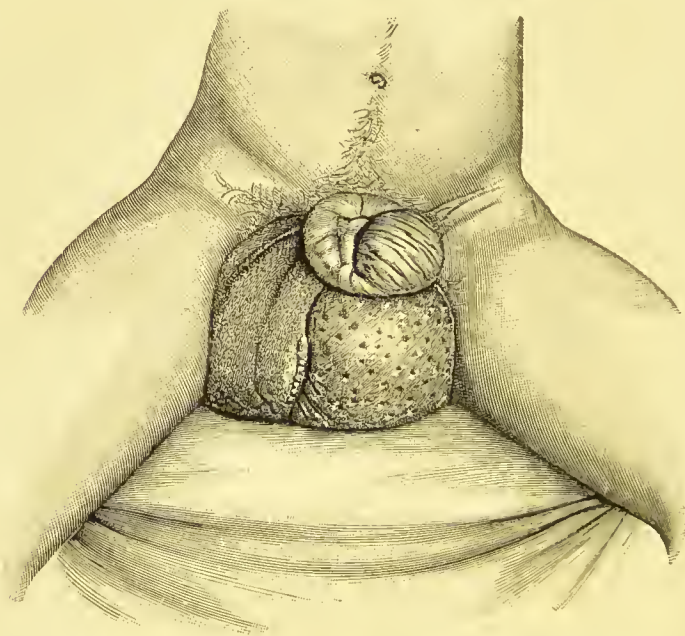


FIG. 90—Elephantiasis of Penis and Scrotum in native of Demerara.

(Mr. Annandale's case.)

ber of such attacks, the lymphatic vessels appear to become obliterated, and the skin and subcutaneous cellular tissue, being bathed in stagnant lymph—which possibly contains the products of streptococci—take on an overgrowth, which continues until the part assumes gigantic proportions. In a certain number of cases the lymphatic trunks have been found to be blocked with the ova or with the parent worms of the *filaria sanguinis hominis*. It must be clearly understood, however, that cases of elephantiasis of the lower extremity are met with in this country in which there are no filarial parasites in the

lymphatics, and these present features indistinguishable from the tropical variety, and usually follow upon repeated attacks of lymphangitis or erysipelas.

The part affected is enormously increased in size, and causes inconvenience from its bulk and weight. In contrast to ordinary dropsy, there is no pitting on pressure, and the swelling does not disappear on elevation of the limb. The skin becomes rough and warty, and may hang down in pendu-



FIG. 91.—Lupus Elephantiasis.
(Sir P. H. Watson's case.)

lous folds. Blisters may form on the surface and yield an abundant exudate of clear lymph. From neglect of cleanliness, the skin may become the seat of eczema or even of ulceration attended with foul discharge.

Sampson Handley has sought to replace the blocked lymphatic vessels by burying in the subcutaneous tissue of the swollen part a number of stout silk threads—*lymphangioplasty*. By their capillary action they drain the lymph to a healthy region above, and thus enable it to enter the

circulation. It has been more successful in the face and upper limb than in the lower extremity. If the tissues are infected with staphylococci, a course of vaccines should precede the operation.

A similar type of elephantiasis may occur after extirpation of the lymphatic glands in the axilla or groin; in the leg in long-standing varix and phlebitis with chronic ulcer; in the arm as a result of extensive cancerous disease of the lymphatics in the axilla secondarily to cancer of the breast; and in extensive tuberculous disease of the lymphatics. The last-named is chiefly observed in the lower limb in young adult women, and from its following upon lupus of the toes or foot it has been called *lupus elephantiasis* (Fig. 91). The tuberculous infection spreads very slowly up the limb by way of the lymphatics, and as these are obliterated the skin and cellular tissue become hypertrophied, and the surface studded over with fungating tuberculous masses of a livid blue colour. As the more severe forms of the disease may prove dangerous to life by septic complications inducing gangrene of the limb, the question of amputation may have to be considered.

Belonging to this group also is a form of *congenital elephantiasis* resulting from the circular constriction of a limb *in utero* by amniotic bands.

Elephantiasis occurring apart from lymphatic or venous obstruction is illustrated by *elephantiasis nervorum*, in which there is an overgrowth of the skin and cellular tissue of an extremity in association with neuro-fibromatosis of the cutaneous nerves (Fig. 85); and by *elephantiasis Græcorum*—a form of leprosy in which the skin of the face becomes the seat of tumour-like masses consisting of leprous nodules. It is also illustrated by *elephantiasis involving the scrotum* as a result of prolonged irritation by the urine in cases in which the penis has been amputated and the urine has infiltrated the scrotal tissues.

Sebaceous Cysts.—Atheromatous cysts or wens are retention cysts formed in relation to the sebaceous glands and hair follicles. They are commonly met with in adults, on the scalp (Fig. 92), face, neck, back, and external genitals. Sometimes they are multiple, and they may be met with in several members of the same family. They are smooth, rounded or discoid cysts, varying in size from a split-pea to a Tangerine orange. In consistence they are firm and elastic, or fluctuating, and are incorporated with the overlying skin, but movable on the deeper structures. The orifice of the partly blocked

sebaceous follicle may be visible, and some of the contents of the cyst can be squeezed through the opening. The wall of the cyst is composed of a connective-tissue capsule lined by stratified squamous epithelium. The contents consist of accumulated epithelial cells, and are at first dry, and pearly white in appearance, but as a result of fatty degeneration they break down into a greyish-yellow pultaceous and semi-fluid material having a peculiar stale odour. It is probable that the decomposition of the cyst contents is the result of the presence of bacteria, and that from the surgical point of view they should be regarded as infective. A sebaceous cyst may remain indefinitely without change, or may slowly increase in size, the



FIG. 92.—Multiple Sebaceous Cysts or Wens ; the larger ones are of many years' duration.

skin over it becoming stretched and closely adherent to the cyst wall as a result of friction and pressure. The contents may become calcareous or may ooze from the orifice of the duct and dry on the skin surface, leading to the formation of a sebaceous horn. As a result of injury the cyst may undergo sudden enlargement from hæmorrhage into its interior.

Recurrent attacks of inflammation frequently occur, especially in wens of the face and scalp. Suppuration may ensue and be followed by cure of the cyst, or an offensive fungating ulcer forms which may be mistaken for epithelioma. True cancerous transformation is rare.

Wens are to be *diagnosed* from dermoids, from fatty tumours, and from cold abscesses. Dermoids usually appear before adult life, and as they nearly always lie beneath the fascia, the skin

is movable over them. A fatty tumour is more movable, and is often lobulated. The confusion with a cold abscess is most likely to occur in wens of the neck or back, and it may be impossible without the use of an exploring needle to differentiate between them.

Treatment.—The removal of wens is to be recommended while they are still small and freely movable, as they are then easily shelled out after incising the overlying skin. Local anæsthesia is to be preferred. It is important that none of the cyst wall be left behind. In large and adherent wens an ellipse of skin should be removed along with the cyst. When inflamed, it may be impossible to dissect out the cyst wall, and it should be destroyed with pure carbolic acid, the resulting wound being treated by the open method.

Moles.—The term mole is applied to a pigmented, and usually hairy, patch of skin, present at or appearing shortly after birth. The colour varies from brown to black, according to the amount of melanin pigment present. The lesion consists in an overgrowth of epidermis which often presents an alveolar arrangement. Moles vary greatly in size: some are mere dots, others are as large as the palm of the hand, and occasionally a mole covers half the face. In addition to being unsightly, they bleed freely when abraded, are liable to ulcerate from friction and pressure, and occasionally become the starting-point of melanotic cancer. Rodent cancer sometimes originates in the slightly pigmented moles met with on the face. Overgrowths in relation to the cutaneous nerves, especially the plexiform neuroma, occasionally originate in pigmented moles. Soldau believes that the pigmentation and overgrowth of the epidermis in moles are associated with, and probably result from, a fibromatosis of the cutaneous nerves.

Treatment.—The best way to get rid of a mole is to excise it. If the edges of the gap cannot be brought together with sutures, recourse should be had to Thiersch grafting. In large hairy moles of the face whose size forbids excision, the hairs may be got rid of by the Röntgen rays.

Horns.—The *sebaceous* horn results from the accumulation of the dried contents of a wen on the surface of the skin; the sebaceous material after drying up becomes cornified, and as fresh material is added to the base the horn increases in length. The *wart* horn grows from a warty papilloma of the skin. *Cicatrix* horns are formed by the heaping up of epidermis in the scars that result from burns. *Nail* horns are overgrown nails (keratomata of the nail-bed), and are met with chiefly in the

great toe of elderly bedridden patients. If an ulcer forms at the base of a horn, it may prove the starting-point of epithelioma, and for this reason, as well as for others, horns should be removed.

New Growths in the Skin and Subcutaneous Tissue.—The *Angioma* has been described with diseases of blood-vessels. *Fibroma*.—Various types of fibroma occur in the skin. Soft pedunculated fibromata, about the size of a pea, are commonly met with, especially on the neck and trunk; they are usually solitary, and easily removed with the scissors. The multiple soft fibromata, known as *molluscum fibrosum*, which depend upon a neuro-fibromatosis of the cutaneous nerves, are described with the tumours of nerves. Hard fibromata occurring singly or in groups may be met with, especially in the skin of the buttock, and may present a local malignancy, recurring after removal like the “recurrent fibroid” of Paget. The “painful subcutaneous nodule” is a solitary fibroma related to one of the cutaneous nerves. The hard fibroma known as *keloid* is described with the affections of scars.

Papilloma.—The *common wart* or verruca is an outgrowth of the surface epidermis. It may be sessile or pedunculated, hard or soft. The surface may be smooth, or fissured and foliated like a cauliflower, or it may be divided up into a number of spines. Warts are met with chiefly on the hands, and are often multiple, occurring in clusters or in successive crops. Multiple warts appear to result from some contagion, the nature of which is unknown; they sometimes occur in an epidemic form among school-children, and show a remarkable tendency to disappear spontaneously. The solitary flat-topped wart which occurs on the face of old people may, if irritated, become the seat of epithelioma.

Treatment.—In the multiple warts of children the health should be braced up by a change to the seaside. A dusting-powder, consisting of boracic acid with 5 per cent. salicylic acid, may be rubbed into the hands after washing and drying. The persistent warts of young adults are best removed after freezing with chloride of ethyl. When cutting is objected to, they may be painted night and morning with salicylic collodion, the epidermis being dehydrated with alcohol before each application.

Venereal warts occur on the genitals of either sex, and may form large cauliflower-like masses on the inner surface of the prepuce or of the labia majora. Although frequently co-existing with gonorrhœa or syphilis, they may occur independently of

these diseases, being probably acquired by contact with another individual suffering from warts (C. W. Cathcart). They give rise to considerable irritation and suffering, and when cleanliness is neglected there may be an offensive discharge.

In advanced cases with large cauliflower-like masses, it is best to remove them by operation. In the female, they are dissected off from the labia; in the male, the prepuce is removed and the warts on the glans are snipped off, with scissors. In milder cases, the warts usually disappear if the parts are kept absolutely dry and clean. A useful dusting-powder is one consisting of calamine and 5 per cent. salicylic acid. The exsiccated sulphate of iron, in the form of a powder, may be employed in cases which resist this treatment.

Lastly, a warty growth of the epidermis may be an accompaniment of lupus—lupus verrucosus—and of moles.

Adenoma.—This is a comparatively rare tumour growing from the glands of the skin. One variety, known as the “tomato tumour,” which apparently originates from the *sweat glands*, is met with chiefly on the scalp and face in women past middle life. These growths are often multiple; the individual tumours vary in size, and the skin, which is almost devoid of hairs, is glistening and tightly stretched over them. A similar tumour may occur on the nose. The *sebaceous adenoma*, which originates from the sebaceous glands, forms a projecting tumour on the face or scalp, and when the skin is irritated it may ulcerate and fungate. The treatment consists in the removal of the tumour along with the overlying skin.

The exuberant masses on the nose known as “lipoma nasi” or “potato nose” are of the nature of sebaceous adenomata, and are removed by shaving them off with a knife until the normal shape of the nose is restored. Healing takes place with remarkable rapidity.

Cancer.—There are several types of primary cancer of the skin, the most important being squamous epithelioma, rodent cancer, and melanotic cancer.

Epithelioma occurs in a variety of forms. When originating in a small ulcer or wart—for example, on the face in old people—it presents the features of a chronic indurated ulcer. A more exuberant and rapidly growing form of epithelial cancer, described by Hutchinson as the *crateriform ulcer*, commences on the face as a small red pimple which rapidly develops into an elevated mass shaped like a bee-hive, and breaks down in the centre. Epithelioma may develop any-

where on the body in relation to scar tissue, especially that resulting from a burn or from lupus; this form usually presents an exuberant outgrowth of epidermis not unlike a cauliflower wart.

The term *trade epithelioma* has been applied to that form met with in certain occupations, such as paraffin workers and chimney-sweeps. The most recent member of this group is the *X-ray carcinoma*, which is met with in those who are constantly exposed to the irritation of the X-rays; there is first a chronic dermatitis with warty overgrowth of the surface epithelium, pigmentation, and the formation of fissures and



FIG. 93.—Advanced Rodent Cancer.

(Mr. Annandale's case.)

warts. It varies a good deal in malignancy, but it has been known to cause death in the same manner as other epitheliomata.

Epithelial cancer has also been observed in those who have taken large doses of arsenic over long periods for medicinal purposes.

Rodent Cancer (Rodent Ulcer).—This is a true cancer originating in the sweat glands or sebaceous follicles, or in the foetal residues of cutaneous glands. The cells are small and closely packed together in alveoli or in reticulated columns; cell nests are very rare. It is remarkably constant in its seat of origin, being nearly always located on the lateral aspect of

the nose or in the vicinity of the lower eyelid (Figs. 94, 95). It is extremely rare on the trunk or limbs. It commences as a small flattened nodule in the skin, the epidermis over it being stretched and shining. The centre becomes depressed, while the margins extend in the form of an elevated ridge. Sooner or later the epidermis gives way in the centre, exposing a smooth raw surface devoid of granulations. The margin, while in parts irregular, is typically represented by a well-defined "rolled" border which consists of the peripheral portion of the cancer that has not yet broken down. The central ulcer may temporarily heal. There is itching but very little pain, and the condition progresses extremely slowly; rodent cancers which



FIG. 94.—Rodent Cancer of Inner Canthus.

have existed for many years are frequently met with. The disease attacks and destroys every structure with which it comes in contact, such as the eyelids, the walls of the nasal cavities, and the bones of the face; hence it may produce the most hideous deformities (Fig. 95). The patient may succumb to hæmorrhage or to septic complications such as erysipelas or meningitis.

Secondary growths in the lymphatic glands, while not unknown, are extremely rare. We have only seen them once—in a case of rodent cancer in the groin.

Diagnosis.—Lupus is the disease most often mistaken for rodent cancer. Lupus usually begins earlier in life, it presents the apple-jelly nodules, and lacks the rounded, elevated border.

Syphilitic lesions progress more rapidly, and also lack the characteristic margin. The differentiation from squamous epithelioma is of considerable importance, as the latter affection spreads more rapidly, involves the glands early, and is much more dangerous to life.

Treatment.—In rodent cancers of limited size—say less than one inch in diameter—free excision is the most rapid and certain method of treatment. The alternative is the application of the Röntgen rays or of radium, which, although requiring many exposures, results in cure with the minimum



FIG. 95.—Rodent Cancer of fifteen years' duration, which has destroyed contents of Orbit.

(Mr. J. M. Cotterill's case.)

of disfigurement. If the cancer already covers an extensive area, or has invaded the cavity of the orbit or nose, rays yield the best results. The effect is soon shown by the ingrowth of healthy epithelium from the surrounding skin, and at the same time the discharge is lessened. Good results are also reported from the application of carbon dioxide snow.

Melanotic Cancer.—Under this head are included all new growths which contain an excess of melanin pigment. Many of these were formerly described as melanotic sarcoma. They nearly always originate in a pigmented mole which has been

subjected to irritation. The primary growth may remain so small that its presence is not even suspected, or it may increase in size, ulcerate, and fungate through the skin. The amount of pigment varies: when small in amount the growth is brown, when abundant it is a deep black. The most remarkable feature is the rapidity with which the disease becomes disseminated along the lymphatics, the first evidence of which is an enlargement of the lymphatic glands. As the primary growth is often situated on the sole of the foot (Fig. 96)

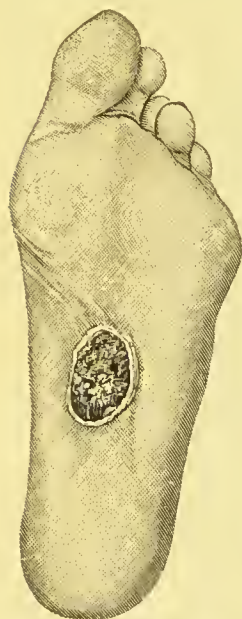


FIG. 96. — Melanotic Cancer of Sole of Foot.

or in the matrix of the nail of the 'great toe, the femoral and inguinal glands become enlarged in succession, forming tumours much larger than the primary growth. Sometimes the dissemination involves the lymphatic vessels of the limb, forming a series of indurated pigmented cords and nodules (Fig. 97). Lastly, the dissemination may be universal throughout the body, and this usually occurs at a comparatively early stage, although it has been delayed in some cases for several years. The secondary growths are deeply pigmented, being usually of a coal-black colour, and melanin pigment may be present in the urine.

To extirpate the disease it is necessary to excise the tumour, with a zone of healthy skin around it and a somewhat large zone of the underlying subcutaneous tissue and deep fascia. Hogarth Pringle recommends that a broad strip of subcutaneous fascia up to and including the nearest anatomical group of glands should be removed with the tumour in one continuous piece.

Secondary Cancer of the Skin.—Cancer may spread to the skin from a subjacent growth by direct continuity or by way of the lymphatics. Both of these processes are so well illustrated in cases of mammary cancer that they will be described in relation to that disease.

Sarcomata of various types are met with in the skin. The fibroma, after excision, may recur as a fibro-sarcoma. The alveolar sarcoma commences as a hard lump and increases in size until the epidermis gives way and an ulcer is formed. A number of fresh tumours may spring up around the original

growth. Sometimes the primary growth appears in the form of multiple nodules which tend to become confluent. Excision, unless performed early, is of little avail.

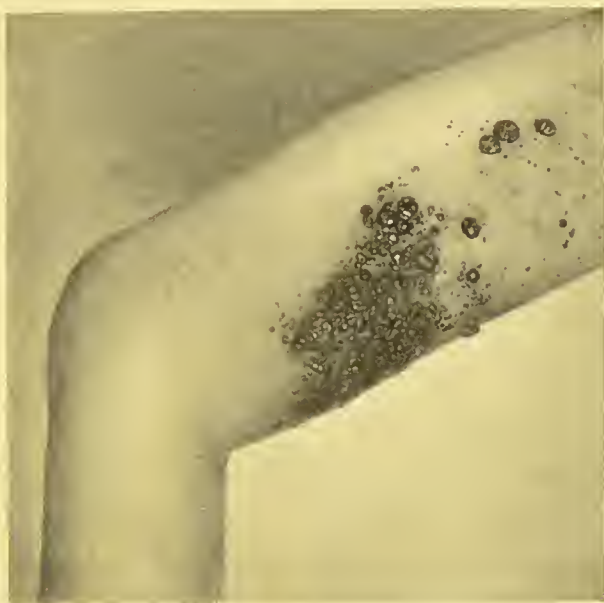


FIG. 97.—Diffuse Melanotic Cancer of Lymphatics of Skin secondary to a Growth in the Sole of the Foot.

AFFECTIONS OF CICATRICES

A cicatrix or scar consists of closely packed bundles of white fibres covered by epidermis; the skin glands and hair follicles are usually absent. The size, shape, and level of the cicatrix depend upon the conditions which preceded healing.

A healthy scar, when recently formed, has a smooth, glossy surface of a pinkish colour, which tends to become whiter as a result of obliteration of the blood-vessels concerned in its formation.

Weak Scars.—A scar is said to be weak when it readily breaks down as a result of irritation or pressure. The scars resulting from severe burns and those over amputation stumps are especially liable to break down from trivial causes. The treatment is to excise the weak portion of the scar and cover the raw surface with skin grafts.

Contracted scars frequently cause deformity either by displacing parts, such as the eyelid or lip, or by fixing parts and preventing the normal movements—for example, a scar on the flexor aspect of a joint (Fig. 61). These are treated by dividing the scar, correcting the deformity, and filling up the gap with Thiersch grafts, or with a flap of the whole thickness of the skin. When deformity results from *depression of a scar*, as is not uncommon after the healing of a sinus, the treatment is to excise the scar. Depressed scars may be raised by the injection of paraffin into the subcutaneous tissue.

The absorption of scar tissue may in some cases be promoted by subcutaneous injections of thiosinamine, in the form of fibrolysin, which appears to act by causing leucocytosis. Two to three cubic centimetres are injected at intervals of two or three days under the skin of the forearm, or into the muscles of the back. A slight odour of garlic may be noticeable in the breath after the injections. After from five to ten injections the bands of scar tissue become softer, and if the treatment is successful it disappears after from fifteen to thirty. The treatment should be combined with movements, massage, hot-air baths, and, in some cases, with passive hyperæmia.

Painful Scars.—Pain in relation to a scar is usually due to nerve fibres being compressed or stretched in the cicatricial tissue; and in some cases to ascending neuritis. The treatment consists in excising the scar or in stretching or excising a portion of the nerve affected.

Pigmented or Discoloured Scars.—The best-known examples are the blue coloration which results from coal-dust or gun-powder, the brown scars resulting from chronic ulcer with venous congestion of the leg, and the variously coloured scars caused by tattooing. The only satisfactory method of getting rid of the coloration is to excise the scar; the edges are brought together by sutures, or the raw surface covered with Thiersch grafts according to the size of the gap.

Hypertrophied Scars.—Scars occasionally broaden out and become prominent, and on exposed parts this may prove a source of disappointment after operations such as those for goitre or tuberculous glands in the neck.

Keloid.—This term is applied to an overgrowth of scar tissue which extends beyond the area of the original wound, and the name is derived from the fact that this extension occurs in the form of radiating processes, suggesting the claws of a crab. It is essentially a fibroma or new growth

of fibrous tissue, which commences in relation to the walls of the smaller blood-vessels; the bundles of fibrous tissue are for the most part parallel with the surface, and the epidermis is tightly stretched over them. It is more frequent in the negro and in those who are, or have been, the subjects of tuberculous disease.

Keloid may attack scars of any kind, such as those resulting from leech-bites, acne pustules, boils or blisters; those resulting from operation or accidental wounds; and the scars resulting from burns, especially when situated over the sternum, are said to be specially liable. The scar becomes more and more conspicuous, is elevated above the surface, of a pinkish or brownish-pink colour, and sends out irregular prolongations around its margins. The patient may complain of itching and burning, and of great sensitiveness of the scar, even to contact with the clothing.

There is a natural hesitation to excise keloid because of the fear of its returning in the new scar. Such return, however, is very unlikely if it is excised widely and the raw surface covered with Thiersch grafts. The irritation associated with keloid may be relieved by the application of salicylic collodion or of salicylic and creosote plaster. Improvement has resulted from injections of fibrolysin and from exposure to X-rays.

Epithelioma is liable to attack scars in old people, especially those resulting from burns sustained early in childhood and which have never properly healed. From the absence of lymphatics in scar tissue, the disease does not spread to the glands until it has invaded the tissues outside the scar area. It should be excised widely; in the extremities it may be best to amputate the limb.

AFFECTIONS OF THE NAILS

Injuries.—When a nail is contused or crushed, blood is extravasated beneath it, and the nail is usually shed, a new one growing in its place. A splinter driven underneath the nail causes great pain, and if organisms are carried in along with it, may give rise to septic complications. The free edge of the nail should be clipped away to allow of the removal of the foreign body and of the necessary disinfection.

Trophic Changes.—The growth of the nails may be interfered with in any disturbance of the general health. In nerve

lesions, such as division of the nerve-trunks of a limb, the nails are apt to suffer, becoming eurved, brittle, or furrowed, or they may be shed.

Onychia is the term applied to inflammation of the soft parts around the nail or of the matrix beneath it. The commonest form of onychia is that resulting from septic infection, which has already been referred to with Whitlow. There is a superficial variety resulting from the extension of a purulent blister beneath the nail lifting it up from its bed, the pus being visible through the nail. The nail as well as the raised horny layer of the epidermis should be removed. A deeper and more troublesome onychia results from infection at the nail fold; the infection spreads slowly beneath the fold

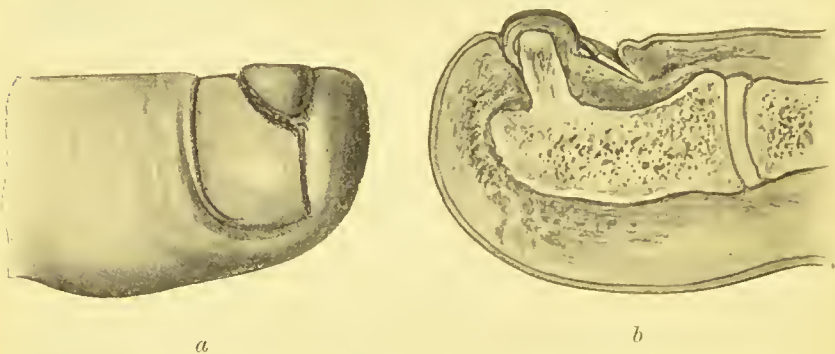


FIG. 98.—Subungual Exostosis growing from Distal Phalanx of Great Toe, showing Ulceration of Skin and Displacement of Nail.

a. Surface view.

b. On section.

until it reaches the matrix, and a drop or two of pus forms beneath the nail, usually in the region of the lunule. This affection entails a disability of the finger which may last for weeks unless it is properly treated. Treatment by hyperæmia, using a suction bell, should first be tried, and failing improvement the nail fold and lunule should be frozen, and a considerable portion removed with the knife; if only a small portion of the nail is removed, the opening is blocked by granulations springing from the matrix. A new nail is formed, but it is liable to be mis-shapen.

Tuberculous onychia is met with chiefly in children and adolescents. It appears as a livid or red swelling at the root of the nail and spreading around its margins. The epidermis, which is thin and shiny, gives way, and the nail is usually shed.

Syphilitic affections of the nails assume various aspects. A primary chancre at the edge of the nail may be mistaken for a whitlow, especially if it is attended with much pain. Other forms of onychia occur during secondary syphilis simultaneously with the skin eruptions, and may prove very obstinate and lead to shedding of the nails. They also occur in inherited syphilis. In addition to general treatment, an ointment containing five per cent. of oleate of mercury should be applied locally.

Ingrowing Toe-nail (lateral onychia).—This is more accurately described as an overgrowth of the soft tissues along the edge of the nail. It is most frequently met with in the great toe in young adults whose feet perspire freely, who wear ill-fitting shoes, and who cut their toe-nails carelessly or tear them with their fingers. Where the soft tissues are pressed against the edge of the nail, the skin gives way and there is the formation of exuberant granulations and of discharge which is sometimes foetid. The affection is a painful one and may unfit the patient for work. In mild cases the condition may be remedied by getting rid of contributing causes and by disinfecting the skin and nail; the nail is cut evenly, and the groove between it and the skin packed with an antiseptic dusting-powder, such as boracic acid. In more severe cases it may be necessary to remove an ellipse of tissue consisting of the edge of the nail, together with the subjacent matrix and the redundant nail-fold.

Subungual exostosis is an osteoma growing from the terminal phalanx of the great toe (Fig. 98). It raises the nail and may be accompanied by ulceration of the skin over the most prominent part of the growth. The soft parts, including the nail, should be reflected towards the dorsum in the form of a flap and the exostosis removed with the chisel.

Malignant disease in relation to the nails is rare. Squamous epithelioma and melanotic cancer are the forms met with. Treatment consists in amputating the digit concerned, and in removing the associated lymphatic glands.

CHAPTER XVIII

THE MUSCLES, TENDONS, AND TENDON SHEATHS

INJURIES: *Contusion; Sprain; Rupture*—Hernia of muscle—Dislocation of tendons—Wounds—Avulsion of tendon. DISEASES OF MUSCLE AND OF TENDONS: *Atrophy; "Muscular rheumatism"—Fibrositis; Contracture; Myositis; Calcification and Ossification; Tumours.* DISEASES OF TENDON SHEATHS: *Teno-synovitis.*

INJURIES

Contusion of Muscle.—Contusion of muscle, which consists in rupture of its fibres and blood-vessels, may be due to violence acting from without, as in blows, kicks, or falls; or from within, as by the displacement of a bone in fractures and dislocations.

The symptoms are those common to all contusions, and the patient complains of severe pain on attempting to use the injured muscle, and maintains an attitude which relaxes it. If the sheath of the muscle also is torn, there is subcutaneous ecchymosis, and the accumulation of blood may result in the formation of a hæmatoma.

Restoration of function is usually complete; but when the nerve supplying the muscle is bruised at the same time, as may occur in the deltoid, wasting and loss of function may be persistent. In exceptional cases the process of repair may be attended with the formation of bone in the substance of the muscle.

A contused muscle should be placed at rest and supported by cotton wool and a bandage—followed, after an interval, by massage, the use of the continuous current, and appropriate exercises.

Sprain and Partial Rupture of Muscle.—This lesion consists in overstretching and partial rupture of the fibres of a muscle or its aponeurosis. It is of common occurrence in athletes and in those who follow laborious occupations. It may follow upon a single or repeated effort—especially in those who are out

of training. Familiar examples of muscular sprain are the "labourer's" or "golfer's back," affecting the latissimus dorsi or erector spinæ; the "tennis-player's elbow," and the "sculler's sprain," affecting the muscles and ligaments about the elbow-joints; the "angler's elbow," affecting the common origin of the extensors and supinators; the "sprinter's sprain," affecting the flexors of the hip; and the "jumper's sprain," affecting the muscles of the calf. The patient complains of pain, often sudden in onset, of tenderness on pressure, and of inability to carry out the particular movement by which the sprain was produced. The disability varies in different cases, and it may incapacitate the patient from following his occupation or sport for weeks or even months.

The *treatment* consists in resting the muscle from the particular effort concerned in the production of the sprain, in gently exercising it in other directions, in the use of massage and the induction of hyperæmia by means of heat.

Rupture of Muscle or Tendon.—A muscle or a tendon may be ruptured in its continuity or torn from its attachment to bone. The site of rupture in individual muscles is remarkably constant, and is usually at the junction of the muscular and tendinous portions. When rupture takes place through the belly of a muscle, the ends retract, the amount of retraction depending on the length of the muscle, and the extent of its attachment to adjacent aponeurosis or bone. The biceps in the arm, and the sartorius in the thigh, furnish examples of muscles in which the separation between the ends may be considerable.

The gap in the muscle becomes filled with blood, and this in time is replaced by connective tissue, which forms a bond of union between the ends. When the space is considerable the connecting medium consists of fibrous tissue, but when the ends are approximated it contains a number of newly formed muscle fibres. In the process of repair, one or both ends of the muscle or tendon may become fixed by adhesions to adjacent structures, and if the distal portion of a muscle is deprived of its nerve supply it may undergo degeneration and so have its function impaired.

Rupture of a muscle or tendon is usually the result of a sudden, and often involuntary, movement. As examples may be cited the rupture of the quadriceps extensor in attempting to regain the balance when falling backwards; of the gastrocnemius, plantaris, or tendo Achillis in jumping or dancing; of the adductors of the thigh in gripping a horse when it

swerves—"rider's sprain"; of the abdominal muscles in vomiting, and of the biceps flexor cubiti in sudden movements of the arm. Sometimes the effort is one that would scarcely be thought likely to rupture a muscle, as in the case recorded by Pagenstecher, where a professional athlete, while sitting at table, ruptured his biceps in a sudden effort to catch a falling glass. It would appear that the rupture is brought about not so much by the contraction of the muscle concerned, as by the contraction of the antagonistic muscles taking place before that of the muscle which undergoes rupture is completed. The violent muscular contractions of epilepsy, tetanus, or delirium rarely cause rupture.

The *clinical features* are usually characteristic. The patient experiences a sudden pain, with a sensation of being struck with a whip, and of something giving way; sometimes a distinct snap is heard. The limb becomes powerless. At the seat of rupture there is tenderness and swelling, and there may be ecchymosis. As the swelling subsides a gap may be felt between the retracted ends, and this becomes wider when the muscle is thrown into contraction. If untreated, a hard, fibrous cord may be felt at the seat of rupture.

Treatment.—The ends are approximated by placing the limb in an attitude which relaxes the muscle, and the position is maintained by bandages, splints, or special apparatus. When it is impossible thus to approximate the ends satisfactorily, the muscle or tendon is exposed by incision, and the ends brought into accurate contact by catgut sutures. This operation of primary suture yields the most satisfactory results, and is most successful when it is done within five or six days of the accident. Secondary suture after an interval of months is rendered difficult by the retraction of the ends and by their adhesion to adjacent structures.

Rupture of the biceps of the arm may involve the long or the short head, or the belly of the muscle. Most interest attaches to rupture of the long tendon of origin. There is pain and tenderness in front of the upper end of the humerus, the patient is unable to abduct or to elevate the arm, and he may be unable to flex the elbow when the forearm is supinated. The long axis of the muscle, instead of being parallel with the humerus, inclines downwards and outwards. When the patient is asked to contract the muscle, its belly is seen to be drawn towards the elbow.

The *adductor longus* may be ruptured, or torn from the pubes, by a violent effort to adduct the limb. A swelling

forms in the upper and inner part of the thigh, which becomes smaller and harder when the muscle is contracted.

The *quadriceps extensor femoris* is usually ruptured close to its insertion into the patella, in the attempt to avoid falling backwards. The injury is sometimes bilateral. The injured limb is rendered useless for progression, as it suddenly gives way whenever the knee is flexed. Treatment is conducted on the same lines as in transverse fracture of the patella; in the majority of cases the continuity of the quadriceps should be re-established by suture within five or six days of the accident.

The *tendo Achillis* is comparatively easily ruptured, and the symptoms are sometimes so slight that the nature of the injury may be overlooked. The limb should be put up with the knee flexed and the toes pointed. This may be effected by attaching one end of an elastic band to the heel of a slipper, and securing the other to the lower third of the thigh. If this is not sufficient to bring the ends into apposition they should be approximated by sutures.

The *plantaris* is not infrequently ruptured from trivial causes, such as a sudden movement in boxing or playing tennis or hockey. A sharp stinging pain like the stroke of a whip is felt in the calf; there is marked tenderness at the seat of rupture, and the patient is unable to raise the heel without pain. The injury is of little importance, and if the patient keeps the heel to the ground in walking, it is recovered from in a couple of weeks or so.

Hernia of Muscle.—This is a rare condition, in which, owing to the fascia covering a muscle becoming stretched or torn, the muscular substance is protruded through the rent. It has been observed chiefly in the adductor longus. An oval swelling forms in the upper part of the thigh, is soft and prominent when the muscle is relaxed, less prominent when it is passively extended, and disappears when the muscle is thrown into contraction. It is liable to be mistaken, according to its situation, for a tumour, a cyst, a pouch vein, or a femoral or obturator hernia. Treatment is only called for when it is causing inconvenience, the muscle being exposed by a suitable incision, the herniated portion excised, and the rent in the sheath closed by sutures.

Dislocation of Tendons.—Tendons which run in grooves may be displaced as a result of rupture of the confining sheath. This injury is met with chiefly in the tendons at the ankle and in the long tendon of the biceps.

Dislocation of the *peronei tendons* may occur, for example,

from a violent twist of the foot. There is severe pain and considerable swelling in the region of the outer ankle; the peroneus longus by itself, or together with the brevis, can be felt on the outer aspect or in front of the external malleolus; the patient is unable to move the foot. By a little manipulation the tendons are replaced in their grooves, and are retained there by a series of strips of plaster. At the end of three weeks massage and exercises are employed.

In other cases there is no history of injury, but whenever the foot is everted the tendon of the peroneus longus is liable to be jerked forwards out of its groove, sometimes with an audible snap. The patient suffers pain and is disabled until the tendon is replaced. Reduction is easy, but as the displacement tends to recur, an operation is required to fix the tendon in its place. An incision is made over the tendon; if the sheath is slack or torn, it is tightened up or closed with catgut sutures; or an artificial sheath is made by raising up a quadrilateral flap of periosteum from the outer aspect of the fibula, and stitching it over the tendon.

Similarly the *tibialis posticus* may be displaced over the internal malleolus as a result of inversion of the foot.

The *long tendon of the biceps* may be dislocated outwards or inwards—usually inwards—as a result of violent or repeated rotation movements of the upper arm, such as are performed in wringing clothes. The patient is aware of the displacement taking place, and is unable to extend the forearm until the displaced tendon has been reduced by abducting the arm. In recurrent cases the patient may be able to dislocate the tendon at will, but the disability is so inconsiderable that there is rarely any occasion for interference.

Wounds of Muscles and Tendons.—When a muscle is implicated in an accidental wound, its ends should be brought together with catgut sutures. If the ends are allowed to retract, and especially if the wound suppurates, they become united by scar tissue and may be fixed to bone or other adjacent structure. In a limb this may interfere with the functions of the muscle; in the abdominal wall the scar tissue may stretch, and so favour the development of a ventral hernia.

Tendons may be cut across accidentally, especially in those wounds so commonly met with above the wrist as a result of the hand being thrust through a pane of glass. It is essential that the ends should be sutured to each other, and as the upper end is retracted the original wound may require to be enlarged in an upward direction. When primary suture has

been omitted, or has failed in consequence of suppuration, the separated ends of the tendon become adherent to adjacent structures, and the function of the associated muscle is impaired or lost. Under these conditions the operation of secondary suture is indicated. A free incision is necessary in order to discover and isolate the ends of the tendon; if the interval is too wide to admit of their being approximated by sutures, means must be taken to lengthen the tendon.



FIG. 99.—Avulsion of Tendon with Terminal Phalanx of Thumb.

(Surgical Museum, University of Edinburgh.)

Injuries of the tendons of the fingers are comparatively common. One of the best known is the partial or complete rupture of the aponeurosis of the extensor tendon close to its insertion into the terminal phalanx—*drop-* or *mallet-finger*. This may result from comparatively slight violence, such as striking the tip of the extended finger against an object, or the violence may be more severe, as in attempting to catch a cricket ball. The terminal phalanx is flexed towards the palm and the patient is unable to extend it voluntarily. The treat-

ment consists in applying a palmar splint a little longer than the digit, secured by a few turns of adhesive plaster. When this fails, or in cases in which the nature of the lesion was not recognised at the time of its occurrence, recourse may be had to operation. Under local anæsthesia, a flap of skin is raised from the dorsum over the terminal interphalangeal joint—which as a rule is found to be open—and the torn aponeurosis is stitched with fine catgut or silk.

Subcutaneous rupture of one or other of the digital tendons in the hand or at the wrist can only be remedied by operation. When some time has elapsed since the accident, the central end may be so retracted that it cannot be brought down into contact with the peripheral end, in which case a slip may be taken from an adjacent tendon; in the case of one of the extensors of the thumb, the extensor carpi radialis longior may be detached from its insertion and stitched to the distal end of the thumb tendon.

Avulsion of Tendons.—This is a rare injury, in which the tendons of a finger or toe are torn from their attachments along with a portion of the digit concerned. In the hand, it is usually brought about by the fingers being caught in the reins of a runaway horse, or being seized in a horse's teeth. It is usually the terminal phalanx that is separated, and with it the tendon of the deep flexor, which ruptures most frequently at its junction with the belly of the muscle in the forearm (Fig. 99). The treatment consists in disinfecting the wound, closing the tendon-sheath, and trimming the mutilated finger so as to provide a useful stump.

DISEASES OF MUSCLE AND TENDONS

Congenital absence of one or more muscles is sometimes met with, usually in association with other congenital deformities. The pectoralis major, for example, may be absent on one or on both sides, without, however, causing any disability, as other muscles enlarge and take on its functions.

Atrophy of Muscle.—There is a form of atrophy or wasting of muscles described as *simple* because the muscle elements are merely diminished in size without undergoing any structural alteration. It is commonly met with as a result of disuse, as when a patient is confined to bed for a long period.

In cases of joint disease, the muscles of the affected region become atrophied more rapidly than is accounted for by disuse

alone, and this is attributed to an interference with the trophic innervation of the muscles reflected from centres in the spinal cord. It is usually more marked in the extensor than in the flexor groups of muscles. Those affected become soft and flaccid, exhibit tremors on attempted movement, and their excitability to the faradic current is diminished.

There is also a form of atrophy described as *neuropathic*, because of its association with lesions of the nervous system. It is most pronounced in lesions of the motor nerve-trunks, probably because vaso-motor and trophic fibres are involved as well as those that are purely motor in function. It is attended with definite structural alterations, the muscle elements first undergoing fatty degeneration, and then being absorbed, and replaced to a large extent by ordinary connective tissue and fat. At a certain stage the muscles exhibit the reaction of degeneration. In the common form of infantile paralysis from disease in the anterior horns of the spinal cord, many fibres undergo fatty degeneration and are replaced by fat, while at the same time there is a regeneration of muscle fibres.

“**Muscular Rheumatism.**”—This clinical term is applied to a group of affections of which lumbago is the best-known example. The group includes lumbago, stiff-neck, and pleurodynia—conditions which have this in common, that sudden and severe pain is excited by movement of the affected part. The nature of the lesion underlying these affections is imperfectly understood, but it would appear to affect mainly the fibrous tissue of muscles, although it may extend from this to aponeuroses, ligaments, periosteum, and the sheaths of nerves. The term *fibrositis* has been applied to it by Sir William Gowers.

In *lumbago—lumbo-sacral fibrositis*—the pain is usually located over the sacrum, the sacro-iliac joint, or the aponeurosis of the lumbar muscles on one or both sides. The amount of tenderness varies, and so long as the patient is still he is free from pain. The slightest attempt to alter the position of the back, however, is attended by pain, which may be so severe as to render him helpless for the moment. The pain is most marked on rising from the stooping or sitting posture, and may shoot down the back of the hip, simulating sciatica, but it is not uncommon for lumbago and sciatica to coexist. Once a patient has suffered from lumbago, it is liable to recur, and an attack may be determined by errors of diet, changes of weather, exposure to cold or unwonted exertion. It is met with chiefly in male adults, and is most apt to occur in those

who are gouty or rheumatic, or are the subjects of oxaluric dyspepsia.

In *painful stiff-neck*, or "rheumatic torticollis," the pain is located in one side of the neck, and is excited by some inadvertent movement. The head is held stiffly on one side as in wry-neck, the patient voluntarily contracting the sterno-mastoid. There may be tenderness over the vertebral spines or in the lines of the cervical nerves, and the sterno-mastoid may undergo atrophy. This affection is not uncommon in children.

In *pleurodynia—intercostal fibrositis*—the pain is in the line of the intercostal nerves, and is excited by movement of the chest, as in coughing, or by any bodily exertion. There is often marked tenderness.

A similar affection is met with in the *shoulder and arm—brachial fibrositis*—especially on waking from sleep. There is acute pain on attempting to abduct the arm, and there may be localised tenderness in the region of the circumflex nerve.

Treatment.—The general treatment is concerned with the diet, attention to the stomach, bowels, and kidneys, and with the correction of any gouty tendencies that may be present. Anti-rheumatic remedies such as salicylates are given for the relief of pain, and for this purpose drugs of the aspirin type are to be preferred, and these may be followed by large doses of iodide of potassium. Great benefit may be derived from massage, and from the induction of hyperæmia by means of heat. Cupping or needling, or, in exceptional cases, hypodermic injections of antipyrin or morphin, may be called for. To prevent relapses of lumbago, the patient must take systematic exercises of all kinds, especially such as bring out the movements of the spinal column and hips.

Contracture of Muscles.—Permanent shortening of muscles may result from the prolonged approximation of their points of attachment, or from structural changes in their substance produced either by injury or by disease. It is a frequent accompaniment, and sometimes a cause of certain deformities, in the treatment of which lengthening of the shortened muscles or their tendons may be an essential step.

Ischaemic Contracture.—Volkmann was the first to describe a form of paralysis followed by contracture, resulting from interference with the arterial circulation. It is most frequently observed in the flexor muscles of the forearm in children and young persons under treatment for fractures in the region of

the elbow joint. There is considerable effusion of blood, the skin is tense, and the muscles, vessels, and nerves are compressed; this is further increased if the elbow is flexed and splints and tight bandages are applied. The muscles acquire a board-like hardness and no longer contract under the will, and passive motion is painful and restricted. Slight contracture of the fingers is usually the first sign of the malady; in time the muscles undergo further contraction, and this brings about a claw-like deformity of the hand. The affected muscles usually show the reaction of degeneration. In severe cases the median and ulnar nerves are also the seat of cicatricial changes (ischæmic neuritis).

By means of splints, the interphalangeal, metacarpo-phalangeal, and wrist joints should be gradually straightened until the deformity is over-corrected (R. Jones). A. S. Taylor advises resection of the radius and ulna sufficient to admit of dorsiflexion of the joints in preference to division of the shortened muscles.

Myositis.—Various forms of inflammation of *pyogenic* origin are met with in muscle, most frequently in relation to pyæmia and to typhoid fever. These may result in overgrowth of the connective-tissue framework of the muscle and degeneration of its fibres, or in suppuration and the formation of one or more abscesses in the muscle substance. Repair may be associated with contracture.

In patients suffering from gonorrhœa a *gonorrhœal myositis* may be met with; it is very painful, but rarely goes on to suppuration.

In the early secondary period of *syphilis*, the muscles may be the seat of dull, aching, nocturnal pains, especially in the neck and back. Reference must also be made to what is known as *syphilitic contracture*, a condition which has been observed chiefly in the later secondary period. The biceps of the arm, and the hamstrings in the thigh, are the muscles most commonly affected. The striking feature is a gradually increasing difficulty of extending the limb at the elbow or knee, and progressive flexion of the joint. The affected muscle is larger and firmer than normal, and its electric excitability is diminished. In tertiary syphilis, individual muscles may become the seat of interstitial myositis or of gummata, and these affections readily yield to anti-syphilitic remedies.

Tuberculous disease in muscle, while usually due to extension from adjacent tissues, is sometimes the result of a primary infection through the blood-stream. Tuberculous nodules are

found disseminated throughout the muscle; the surrounding tissues are indurated, and central necrosis may take place and lead to abscess formation and sinuses. We have observed this form of tuberculous disease in the gastrocnemius and in the psoas—in the latter muscle apart from tuberculous disease in the vertebræ.

Tendinitis.—German authors describe an inflammation of tendon as distinguished from inflammation of its sheath, and give it the name tendinitis. It is met with most frequently in the tendo Achillis in gouty and rheumatic subjects who have overstrained the tendon, especially during cold and damp weather. There is localised pain which is aggravated by walking, and the tendon is sensitive and swollen from a little above its insertion to its junction with the muscle. Gouty nodules may form in its substance. Constitutional measures, massage, and douching should be employed. The tendon should be protected from strain. The foot having been placed in the attitude of slight plantar flexion, a broad strip of plaster is applied from the middle of the calf, over the heel to the middle of the sole, and over this additional strips are applied at right angles.

Calcification and Ossification in Muscles, Tendons, and Fasciæ—*Myositis ossificans.*—Reference may be made in the first place to the ossifications which occur in muscles, tendons, fasciæ, and ligaments, in those who are the subjects of arthritis deformans. They are seldom recognised clinically, but are frequently met with in the dissecting-room and in museums. Similar localised ossifications are met with in Charcot's disease of joints, and in fractures which have repaired with exuberant callus. The new bone may be in the form of spicules, plates, or irregular masses, which, when connected with a bone, are called *false* or *spurious exostoses* (Fig. 100).

Traumatic Ossification in relation to Muscle.—Various forms of ossification are met with in muscle as the result of a single or of repeated injury. Ossification in the crureus or vastus externus muscle has been most frequently observed as a result of a kick from a horse. Within a week or two a tumour appears at the site of injury, and becomes progressively harder until its consistence is that of bone. If the tumour moves with the affected muscle, it causes but little inconvenience. If, as is commonly the case, it is fixed to the subjacent bone, the action of the muscle is impaired, and the patient complains of pain and difficulty in flexing the knee. A skiagram shows the extent of the mass and its

relationship to the femur. The treatment consists in excising the bony mass. In some cases a hæmatoma with a fibrous wall and smooth lining membrane is found overlying the bony tumour.

A similar ossification has been observed in relation to the insertion of the brachialis anticus as a sequel of dislocation of the elbow. After successful reduction of the dislocation, the range of movement gradually diminishes and a hard swelling appears in front of the lower end of the humerus.



FIG. 100.—Ossification in Tendon of Ilio-psoas Muscle.

Ossification in the adductor longus was first described by Billroth under the name of "rider's bone." It is due to bruising and partial rupture of the muscle, and has been observed chiefly in cavalry soldiers. If it causes inconvenience when riding, it may be removed by operation.

Ossification in the deltoid and pectoral muscles has been observed in foot-soldiers in the German army, and has received the name of "drill-bone"; it is due to bruising of the muscle by the recoil of the rifle.

The manner in which the bone is formed in these traumatic ossifications is still the subject of controversy. The popular view is that a portion of periosteum is partly or completely detached, and, becoming embedded in the muscle, there continues its bone-forming functions ; instead of a visible portion of periosteum, it may be merely the cellular elements that are displaced. Another view is that the interstitial connective tissue of muscle is the morphological equivalent of periosteum, and may itself form bone—as it undoubtedly does in progressive ossifying myositis—under the stimulus of a single or of repeated traumata.

Progressive Ossifying Myositis.—This is a rare and interesting disease, in which the muscles, tendons, and fasciæ throughout the body become the seat of ossification. It affects almost exclusively the male sex, and usually begins in childhood or

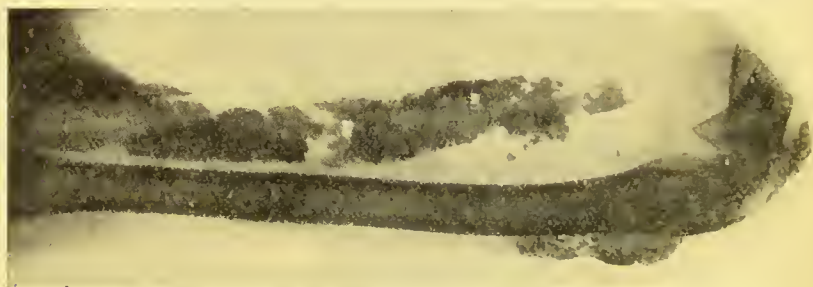


FIG. 101.—Calcification and Ossification in Biceps and Triceps.
(From a radiogram lent by Dr. C. A. Adair Dighton.)

youth, sometimes after an injury, sometimes without apparent cause. The muscles of the back, especially the trapezius and latissimus, are the first to be affected, and the initial complaint may be of limitation of movement.

On examining the affected muscles, swellings are found which are rounded or oval, firm and elastic, sharply defined, without tenderness and without discoloration of the overlying skin. It has been observed in some cases that these swellings come and go before the permanent bony masses are formed. Skiagrams show that a considerable deposit of lime salts may precede the formation of bone, as is seen in Fig. 101. In course of time the spine becomes rigid, the head is bent forward, the hips are flexed, and abduction and other movements of the arms are limited. The disease progresses by fits and starts, until all the striped muscles of the body may be replaced by bone, and all movements, even those of the jaws, may be

abolished. It is generally fatal within ten or twelve years from its onset, death usually resulting from pulmonary complications.

There is no means of arresting the disease, and surgical treatment is restricted to the removal of any mass of bone that interferes with an important movement.

A remarkable feature of this disease is the frequent presence of a deformity of the great toes, which usually takes the form of hallux valgus, the great toes coming to lie beneath the second toes; the shortening is usually ascribed to absence of the first phalanx, but it has been shown to depend also on a synostosis and imperfect development of the phalanges of the toes. A similar deformity of the thumbs is sometimes met with.

Microscopical examination of the muscles shows that prior to the deposition of lime salts and the formation of bone, there occurs a marked proliferation of the intra-muscular connective tissue and a gradual replacement and absorption of the muscle fibres. The bone is spongy in character, and its development takes place along similar lines to those normally observed in the periosteum.

Tumours of Muscle.—With the exception of certain rare congenital varieties, such as the rhabdomyoma, tumours of muscle grow from the connective-tissue framework and not from the muscle fibres. Innocent tumours, such as the fibroma, lipoma, angioma, and neuro-fibroma, are rare. The angioma of muscle, like angiomata in other situations, is chiefly met with in young people; it may be circumscribed or diffuse, and the overlying skin is usually normal. Malignant tumours may be primary in the muscle, or may result from extension from adjacent growths—for example, implication of the pectoral muscle in cancer of the breast—or they may be derived by metastasis from tumours situated elsewhere. The diagnosis of an intra-muscular tumour is made by observing that the swelling is situated beneath the deep fascia, that it becomes firm and fixed when the muscle is contracted, and that, when the muscle is relaxed, it becomes softer, and can be moved in the transverse axis of the muscle, but not in its long axis. The same remarks apply to a gumma or mass of bone within the muscle.

Clinical interest chiefly attaches to that form of slowly growing fibro-sarcoma—the *recurrent fibroid of Paget*—which is most-frequently met with in the muscles of the abdominal wall. A rarer variety is the ossifying chondro-sarcoma, which

may undergo ossification to such an extent as to be visible in skiagrams.

In primary sarcoma the treatment consists in removing the muscle. In the limbs, the function of the muscle that is removed may be retained by transplanting an adjacent muscle in its place. We have carried this out in an ossifying sarcoma of the muscles of the calf by stitching the divided peroneus longus into the tendo Achillis.

Hydatid cysts of muscle are rare.

DISEASES OF TENDON SHEATHS

Tendon sheaths have the same structure and function as the synovial membranes of joints, and are liable to the same diseases. Beyond the limits of the tendon sheaths ordinarily displayed in anatomical dissections, there is a loose peritendinous and peri-muscular cellular tissue which is subject to the same inflammatory affections as the tendon sheaths proper.

Teno-synovitis.—The toxic or infective agent is either conveyed to the tendon sheaths through the blood-stream, as in the gouty, gonorrhœal, and tuberculous varieties, or is introduced directly through a wound, as in the common septic form of teno-synovitis.

Teno-synovitis crepitans.—In the simple or traumatic form of teno-synovitis, although the most prominent etiological factor is a strain or over-use of the tendon, there would appear to be some other, probably a toxic, factor in its production, otherwise the affection would be much more common than it is: only a very small proportion of those who strain or over-use their tendons become the subjects of teno-synovitis. The opposed surfaces of the tendon and its sheath are covered with fibrinous lymph, so that there is friction when they move on one another.

The *clinical features* are pain on movement, tenderness on pressure over the affected tendon, and a sensation of crepitation or friction when the tendon is moved in its sheath. The crepitation may be soft like the friction of snow, or may resemble the creaking of new leather—"saddle-back creaking." There may be swelling in the long axis of the tendon, and redness and œdema of the skin. If there is an effusion of fluid into the sheath, the swelling is more marked and crepitation is absent. There is little tendency to the formation of adhesions.

In the upper extremity, the sheath of the long tendon of the biceps may be affected, but the condition is most common in the tendons about the wrist, particularly in the extensors of the thumb, and it is most frequently met with in those who follow occupations which involve prolonged use or excessive straining of these tendons, for example, washerwomen or riveters. It also occurs as a result of excessive piano-playing, fencing, or rowing.

At the ankle it may affect the peronei, the extensor longus digitorum, or the tibialis anticus. It is most often met with in relation to the tendo Achillis—*Achillo-dynia*—and results from the pressure of ill-fitting boots or from the excessive use and strain of the tendon in cycling, walking, or dancing. There is pain and difficulty in raising the heel from the ground, and creaking can be felt on palpation.

The treatment consists in producing hyperæmia by Bier's method, and resting the affected tendon; in the case of the extensors of the thumb, a splint commanding the forearm and hand is applied. Pain is relieved by lead and opium fomentations or by painting the part with belladonna and glycerine. The affection readily subsides under treatment, but is liable to relapse on a repetition of the exciting cause.

Gouty Teno-synovitis.—A deposit of urate of soda beneath the endothelial covering of tendons or of that lining their sheaths is commonly met with in gouty subjects. The accumulation of urates may result in the formation of visible nodular swellings, varying in size from a pea to a cherry, attached to the tendon and moving with it. They may be merely unsightly, or they may interfere with the use of the tendons. Recurrent attacks of inflammation sometimes occur. We have removed such gouty masses with satisfactory results.

Suppurative Teno-synovitis.—This form usually follows upon infected wounds of the fingers—especially of the thumb or little finger—and is a frequent sequel to whitlow; it may also follow amputation of a finger. Once the infection has gained access to the sheath, it tends to spread, and may reach the palm or even the forearm, being then associated with cellulitis and causing considerable pain, swelling, and high temperature. In moderately acute cases the tendon and its sheath become covered with granulations, which subsequently lead to the formation of firm adhesions; while in more acute cases the tendon sloughs. The pus may burst into the cellular tissue outside the sheath, and the suppuration is liable to spread

to neighbouring sheaths or to adjaacent bones or joints—for example, those of the wrist.

The *treatment* consists in inducing hyperæmia and making small incisions for the escape of pus. The site of incision can usually be determined by the point of greatest tenderness on pressure. After the inflammation has subsided, active and passive movements are employed to prevent the formation of adhesions between the tendon and its sheath. If the tendon sloughs, the dead portion should be cut away, as its separation is extremely slow and is attended with prolonged suppuration.

Gonorrhœal Teno-synovitis.—This is met with especially in the tendon sheaths about the wrist and ankle. It may occur in a mild form, with pain, impairment of movement, and œdema, and sometimes an elongated, fluctuating swelling develops, the result of serous effusion into the sheath. This condition may alternate with a gonorrhœal affection of one of the large joints. It may subside under rest and soothing applications, but is liable to relapse. In the more severe variety the skin is red, and the swelling partakes of the characters of a phlegmon with threatening suppuration. Even if pus forms in the sheath, the tendon rarely sloughs. The treatment consists in inducing hyperæmia by Bier's method; and we have used an anti-gonococcic serum, and also a vaccine, with satisfactory results.

Tuberculous Disease of Tendon Sheaths.—This is a comparatively common affection, and is analogous to tuberculous disease of the synovial membrane of joints. It may originate in the sheath, or may spread to it from an adjaacent bone.

The commonest form—hydrops—is that in which the synovial sheath is distended with a viscous fluid, and the fibrinous material on the free surface becomes detached and is moulded into melon-seed bodies by the movement of the tendon. The sheath itself is thickened by the growth of tuberculous granulation tissue, which subsequently undergoes degeneration. The bodies vary greatly in size and shape, are smooth and of a dull-white colour. There may be an overgrowth of the fatty fringes of the synovial sheath, a condition described as “arborescent lipoma.”

The *clinical features* vary with the tendon sheath affected. In the common flexor sheath of the hand an hour-glass-shaped swelling is formed, bulging above and below the annular ligament—formerly known as *compound palmar ganglion*. There is little or no pain, but the fingers tend to be stiff and

weak, and they may become flexed. On palpation, it is usually possible to displace the contents of the sheath from one compartment to the other, and this may yield fluctuation, and, what is more characteristic, a peculiar soft crepitant sensation from the movement of the melon-seed bodies against one another. In the sheath of the peronei or other tendons about the ankle, the swelling is sausage-shaped, and is constricted opposite the annular ligament.

The onset and progress of the affection are most insidious, and the condition may remain stationary for long periods. It is aggravated by use or strain of the tendons involved. In exceptional cases the skin is thinned and gives way, leading to the formation of a discharging sinus.

Treatment.—In the common flexor sheath of the palm, an attempt may be made to cure the condition by removing the contents through a small incision and filling the cavity with iodoform glycerine, followed by the use of Bier's bandage. If this fails, the distended sheath is laid open, the contents removed, the wall scraped, and the wound closed. During the after treatment it is important to maintain movement of the fingers.

A less common form of tuberculous disease is that in which the sheath becomes the seat of a *diffuse tuberculous thickening*, not unlike the white swelling met with in joints, and with a similar tendency to caseation. There is an absence of fluid and of melon-seed bodies. A painless swelling of an elastic character forms in relation to the tendon sheath. It is hour-glass-shaped in the common flexor sheath of the palm, elongated or sausage-shaped in the extensors of the wrist and in the tendons at the ankle. Although resembling the previous form in being slow in progress and of long duration, it is more liable to result in invasion of the tendons and interference with their functions. It is also more liable to break down and lead to the formation of abscesses and sinuses, and in our experience is more often associated with disease in an adjacent bone or joint. In the peronei tendons, for example, it may result from disease of the fibula or of the ankle-joint.

As a rule the diagnosis is easy, but the local appearances closely resemble those of innocent tumours of tendon sheaths.

When conservative measures fail, excision of the affected sheath should be performed; the whole of the diseased area being exposed by free incision of the overlying soft parts; the sheath carefully isolated from the surrounding tissues and cut across above and below. Any tuberculous tissue on the tendon

itself is removed with a sharp spoon. Associated bone or joint lesions are dealt with at the same time. In the after-treatment the functions of the tendons must be preserved by voluntary and passive movements.

Syphilitic Affections of Tendon Sheaths.—These closely resemble the syphilitic affections of the synovial membrane of joints. During the secondary period the lesion usually consists in effusion into the sheath; gummata are met with during the tertiary period.

Tumours of Tendon Sheaths.—Innocent tumours, such as *lipoma*, *fibroma*, and *myxoma*, are very rare. Their clinical features resemble tuberculous disease so closely that the diagnosis is often extremely difficult. Special mention should be made of the *myeloma* which is met with at the wrist or ankle as an elongated swelling of slow development, or over the phalanx of a finger as a small rounded swelling. The tumour tissue, when exposed by dissection, is of a chocolate or chamois-yellow colour, and consists almost entirely of giant cells. The treatment consists in dissecting the tumour tissue off the tendons, and this is usually successful in bringing about a permanent cure.

All varieties of *sarcoma* are met with, but their origin from tendon sheaths is not associated with any special features. In removing them it may be necessary to sacrifice the tendons or to amputate the limb.

CHAPTER XIX

THE BURSÆ

Anatomy—Normal and adventitious bursæ—Injuries: Bursal hæmatoma—DISEASES: Traumatic or trade bursitis; Bursal hydrops; Solid bursal tumour; Gonorrhœal and suppurative forms of bursitis; Tuberculous and syphilitic disease—Tumours—*Diseases of individual bursæ in the upper and lower extremities.*

A BURSA is a closed sac lined by endothelium and containing synovia. Some are normally present—for instance, that between the skin and the patella, and that between the aponeurosis of the gluteus maximus and the great trochanter. *Adventitious bursæ* are developed as a result of abnormal pressure, for example, over the tarsal bones in cases of club-foot.

Injuries of Bursæ.—As a result of contusion, especially in bleeders, hæmorrhage may occur into the cavity of a bursa and give rise to a *bursal hæmatoma*. Such a hæmatoma may mask a fracture of the bone beneath—for example, fracture of the olecranon process. Acute suppuration is a frequent sequel of infected wounds.

Diseases of Bursæ.—The lining membrane of bursæ resembles that of joints and tendon sheaths, and is liable to the same forms of disease.

Trade or Traumatic Bursitis.—This term may be conveniently applied to certain affections of bursæ which appear to result from repeated slight traumatism incident to particular occupations. The most familiar examples of these are the enlargement of the prepatellar bursa met with in housemaids—the “housemaid’s kneec” (Fig. 102); the enlargement of the olecranon bursa—“miner’s elbow”; and of the ischial bursa—“weaver’s” or “tailor’s bottom” (Fig. 105). These affections are characterised by an effusion of fluid into the sac of the bursa with more or less thickening of its lining membrane. While friction and pressure are the most evident factors in their

production, it is probable that there is also some toxic agent concerned, otherwise these affections would be much more common than they are. Of the countless housemaids in whom the prepatellar bursa is subjected to friction and pressure, only a small proportion become the subjects of housemaid's knee.

Clinical Features.—As these are best illustrated in the different varieties of prepatellar bursitis, it is convenient to take this as the type. In a number of cases the inflammation is acute and the patient is unable to use the limb; the part is hot, swollen, and tender, and fluctuation can be detected in the bursa. In the majority of cases the condition is chronic, and the chief feature is the gradual accumulation of fluid constituting the *bursal hydrops* or *hygroma*. When the affection has lasted some time, or has frequently relapsed, the wall of the



FIG. 102.—Hydrops of Prepatellar Bursa in a housemaid.

bursa becomes thickened by fibrous tissue, which may be deposited irregularly, so that septa, bands or fringes are formed not unlike those met with in arthritis deformans. These fringes may be detached and form loose bodies like those met with in joints: less frequently there are fibrinous bodies of the melon-seed type, sometimes moulded into circular discs like wafers. The presence of irregular thickenings of the wall, or of loose bodies, may be recognised on palpation, especially in superficial bursæ, if the sac is not tensely distended with fluid. The thickening of the wall may take place in a uniform and concentric fashion, resulting in the formation of a fibrous tumour—the *solid bursal tumour*—a small cavity containing a little fluid remaining in the centre.

The *treatment* varies according to the variety and stage of the affection. In recent cases the symptoms subside under rest and the application of fomentations. Hydrops may be got rid

of by blistering, by tapping, or by incision and drainage. When the wall is thickened, the most satisfactory treatment is to excise the bursa; the overlying skin being reflected downwards or outwards in the shape of a horse-shoe flap.

Other Diseases of Bursæ are associated with *gonorrhœal infection*, and with *rheumatism*, especially that following scarlet fever, and are apt to be very persistent or to relapse after apparent cure. In the *gouty* form, urate of soda is deposited in the wall of the bursa, and may result in the formation of chalky tumours, sometimes of considerable size (Fig. 103).

The *suppurative form* may be due to the extension of infection from adjacent tissues—for example, from suppuration in a joint or in the cellular tissue; but it usually results from an infected wound implicating the bursa, or the skin and subcutaneous tissue over it. It is frequently met with in the olecranon bursa after a fall on the elbow, or in the prepatellar bursa from a similar injury to the knee. The skin is red, and there is great swelling and œdema of the part, and, if untreated, the septic process may transgress the wall of the bursa, invade the surrounding cellular tissue, and spread up and down the limb, simulating a spreading erysipelas.

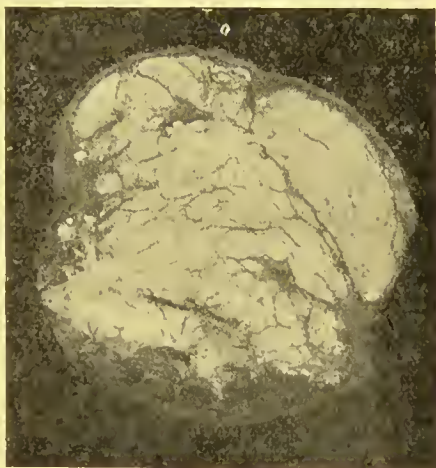


FIG. 103.—Section through Bursa over external malleolus, showing deposit of urate of soda. (Cf. Fig. 108.)

Tuberculous disease of bursæ closely resembles that of tendon sheaths. It may occur as an independent affection, or may be associated with tuberculous disease in an adjacent bone or joint. It is met with chiefly in the prepatellar and subdeltoid bursæ, or in one of the bursæ over the great trochanter. The clinical features are those of an indolent hydrops, with or without melon-seed bodies, or of uniform thickening of the wall of the bursa; the tuberculous granulation tissue may break down into a cold abscess, and give rise to persistent sinuses. The best treatment is to excise the affected bursa, or, when this is impracticable, to lay it freely open, remove the tuberculous tissue with the sharp spoon, and treat the resulting cavity by the open method.

Syphilitic disease is rarely recognised except in the form of bursal and peri-bursal gummata in front of the knee-joint.

Tumours of bursæ include the fibroma, the myxoma, the myeloma or giant-celled tumour, and various forms of sarcoma.

Diseases of Individual Bursæ.—The *olecranon bursa* is frequently the seat of septic infection and of traumatic or trade bursitis, the latter being known as “miner’s” or “student’s elbow.”



FIG. 104.—Tuberculous Disease of Sub-Deltoid Bursa.

(From a photograph lent by Sir George T. Beatson.)

The *sub - deltoid* or *sub-acromial bursa*, which usually presents a single cavity and does not normally communicate with the shoulder-joint, is indispensable in abduction and rotation of the humerus. It is liable to traumatic affections from a fall on the shoulder, pressure, or over-use of the limb. Pain is a constant symptom and is especially annoying at night, the patient being unable to get into a comfortable position. Local tenderness may be elicited over the anatomical limits of the bursa and

is usually most marked over the great tuberosity, just external to the bicipital groove. Demonstrable effusion is not uncommon but is disguised by the overlying tissues. If left to himself, the patient tends to maintain the limb in the sling position and resists movements in the direction of abduction and rotation. In the treatment of this affection the arm should be maintained at a right angle to the body, the upper arm being rotated inwards (Codman). When pain permits of it, movements of the arm and massage are persevered with. In neglected cases,

when adhesions have formed and the shoulder is fixed, it may be necessary to break down the adhesions under an anæsthetic.

The bursa is also liable to infective conditions, such as acute rheumatism, gonorrhœa, suppuration, or tubercle. In tuberculous disease a large fluctuating swelling may form and acquire the characters of a cold abscess (Fig. 104).

The bursa underneath the tendon of the *subscapularis* muscle when inflamed causes alteration in the attitude of the shoulder and impairment of its movements.

An adventitious bursa forms over the *acromion* process in porters and others who carry weights on the shoulder, and may be the seat of traumatic bursitis.



FIG. 105.—Great Enlargement of the Ischial Bursa.

(Mr. Scot-Skirving's case.)

The bursa under the *radial tendon of the biceps*, when the seat of disease, is attended with pain and swelling at the insertion of the biceps tendon about a finger's-breadth below the bend of the elbow; there is pain and difficulty in effecting the combined movement of flexion and supination, slight limitation of extension, and restriction of pronation.

In the lower extremity, a large number of normal and adventitious bursæ are met with. That over the *tuberosity of the ischium*, when enlarged as a trade disease, is known as "weaver's" or "tailor's bottom." It may form a fluctuating swelling of great size, projecting on the buttock and extending down the thigh, and causing great inconvenience in sitting (Fig. 105).

There are two bursæ over the *great trochanter*, one superficial to, the other beneath the aponeurosis of the gluteus

maximus; the latter is not infrequently infected by tuberculous disease spreading from the trochanter.

The bursa *between the psoas muscle and the capsule of the hip-joint* may be the seat of tuberculous disease, and give rise to, clinical features not unlike those of disease of the joint. The limb is flexed, abducted and rotated out, there is a distinct swelling in the upper part of Scarpa's triangle, but the movements are not restricted in directions which do not entail putting the ilio-psoas muscle on the stretch.

The bursa beneath the quadriceps extensor—*subcrural bursa*



FIG. 106.—Bilateral Hydrops of Subcrural Bursa.

(Mr. F. M. Caird's case.)



FIG. 107.—Enlarged Semi-membranosus Bursa.

—usually communicates freely with the knee-joint and shares in its diseases. When shut off from the knee it may suffer independently, and when distended with fluid forms a horse-shoe swelling above the patella (Fig. 106).

In front of the patella and its ligament is the *prepatellar bursa*, which may have one, two, or three compartments, usually communicating with one another. It is the seat of the affection known as housemaid's knee (Fig. 102).

The bursa *between the ligamentum patellæ and the tibia* is very rarely the seat of independent disease. When it is, there is

pain and tenderness referred to the ligament, the patient is unable to extend the limb completely, the tubercle of the tibia is apparently enlarged, and there is a fluctuating swelling on either side of the ligament, most marked in the extended position of the limb.

Of the numerous bursæ in the popliteal space, that *between the semi-membranosus and the inner head of the gastrocnemius* is most frequently the seat of disease, which is usually of the nature of a simple hydrops, forming a fluctuating egg- or sausage-shaped swelling at the inner side of the popliteal space (Fig. 107). It is flaccid in the flexed, and tense in the



FIG. 108.—Gouty Disease of Bursæ in a tailor. The bursal tumours were almost entirely composed of urate of soda. (Cf. Fig. 103.)

extended position of the limb. As a rule it causes little inconvenience, and may be left alone. Otherwise it should be dissected out, and if, as is frequently the case, there is a communication with the knee-joint, this should be closed with sutures.

An adventitious bursa may form over the *external malleolus*, especially in tailors, giving rise to the condition known as "tailor's ankle" (Fig. 108).

The bursa *between the tendo Achillis and the upper part of the os calcis* may become inflamed—especially as a result of post-scarletinal rheumatism or gonorrhœa. The affection is known as Achillo-bursitis. There is severe pain in the region of the insertion of the *tendo Achillis*, the movements at the

ankle-joint are restricted, and the patient may be unable to walk. There is a tender swelling on either side of the tendon. When, in spite of palliative treatment, the affection persists or relapses, it is best to excise the bursa. The tendo Achillis is detached from the os calcis, the bursa dissected out, and the tendon replaced. If there is a bony projection from the os calcis, as sometimes occurs, it should be shaved off with the chisel.

The bursa that is sometimes met with on the under aspect of the os calcis—the *subcalcanean bursa*—when inflamed, gives rise to marked local pain and tenderness in the sole of the foot. This affection may be associated with a spinous projection from the bone, which is capable of being recognised in a skiagram. The soft parts of the heel are turned forwards as a flap, the bursa is dissected out, and the projection of bone, if present, is removed.

The enlargement of adventitious bursæ over the head of the first metatarsal in hallux valgus; over the tarsus, metatarsus, and digits in the different forms of club-foot; over the angular projection in Pott's disease of the spine; over the end of the bone in amputation stumps, and over hard tumours such as chondroma and osteoma, are described elsewhere.

CHAPTER XX

INJURIES OF BONES

Contusions—Wounds—FRACTURES: *Pathological; Traumatic; Varieties*
—Simple fractures—Compound fractures—SEPARATION OF EPI-
PHYSES—Repair of fractures—Interference with repair.

THE injuries to which a bone is liable are Contusions, Open Wounds, and Fractures.

Contusions of Bone are almost of necessity associated with similar injuries of the overlying soft parts. The mildest degree consists in a bruising of the periosteum, which is raised from the bone by an effusion of blood, constituting a *hæmatoma of the periosteum*. This may be rapidly and completely absorbed, or it may give place to a persistent thickening of the bone—*traumatic node*.

For the first few days the limb should be elevated and fomented, and later, massage and the internal administration of potassium iodide favour the absorption of effusions and nodes.

Open Wounds of Bone of the incised and contused varieties are usually produced by sabres, axes, butchers' knives, scythes, or circular saws. Punctured wounds are caused by bayonets, arrows, or other pointed instruments. They are all equivalent to compound, incomplete fractures.

Gun-shot injuries of bone have already been described.

FRACTURES

A fracture may be defined as a sudden and violent solution in the continuity of a bone.

PATHOLOGICAL OR SPONTANEOUS FRACTURES

A pathological or spontaneous fracture has as its primary cause some diseased state of the bone, which permits of its

giving way on the application of a force which would be quite insufficient to break a healthy bone, and which merely hastens its complete severance. It cannot be too strongly emphasised that when a bone is found to have been broken by a slight degree of violence, the presence of some pathological condition should be suspected, and a careful examination made with the X-rays and by other means, before the injury is treated. Many cases are on record in which such an accident has first drawn attention to the presence of a new growth or other serious lesion in the bone. The following conditions, which will be more fully described with diseases of bone, may be mentioned as predisposing to pathological fractures.

Atrophy of bone may proceed to such an extent in old people, or in those who for long periods have been bed-ridden, that the slightest violence suffices to determine a fracture. This most frequently occurs in the neck of the femur in old women, the mere catching of the foot in the bed-clothes while the patient is turning in bed being sometimes sufficient to cause the break. Atrophy from the pressure of an aneurysm or of a simple tumour may erode the whole thickness of a bone, or may thin it out to such an extent that very slight force is sufficient to break it. In general paralysis, and in the advanced stages of locomotor ataxia and other chronic diseases of the nervous system, an atrophy of all the bones sometimes takes place, and may proceed so far that multiple fractures are induced by trifling causes. They occur most frequently in the ribs or long bones of the limbs, are not attended with pain, and usually unite satisfactorily, although with an excessive amount of callus. Attendants and nurses must be warned against using force in handling such patients, as otherwise they may be unfairly blamed for causing these fractures.

Among diseases which affect the skeleton as a whole and render the bones abnormally fragile, the most important are rickets, osteomalacia, and fibrous osteomyelitis. In these conditions multiple pathological fractures frequently occur, and they are prone to heal with considerable deformity.

Of the diseases affecting individual bones and predisposing them to fracture may be mentioned suppurative osteomyelitis, tuberculosis, syphilitic gummata, and various forms of new-growth, particularly sarcoma and secondary cancer. It is not unusual for the sudden breaking of the bone to be the first intimation of the presence of a new-growth.

Intra-uterine fractures and fractures occurring *during birth*

are usually associated with some form of violence, but in the majority of cases the foetus is the subject of some constitutional disease which renders the bones unduly fragile.

TRAUMATIC FRACTURES

Traumatic fractures are usually the result of a severe force acting from without, although sometimes they are produced by muscular contraction.

When the bone gives way at the point of impact of the force, the violence is said to be *direct*, and a "fracture by compression" results, the line of fracture being as a rule transverse. The soft parts overlying the fracture are more or less damaged according to the weight and shape of the impinging body. Fracture of both bones of the leg from the passage of a wheel over the limb, fracture of the shaft of the ulna in warding off a stroke aimed at the head, and fracture of a rib from a kick, are illustrative examples of fractures by direct violence.

When the force is transmitted to the seat of fracture from a distance, the violence is said to be *indirect*, and the bone is broken by "torsion" or by "bending." In such cases the bone gives way at its weakest point, and the line of fracture tends to be oblique. Thus both bones of the leg are frequently broken by a person jumping from a height and landing on the feet, the tibia breaking in its lower third, and the fibula at a higher level. Fracture of the clavicle in its middle third, or of the radius at its lower end, from a fall on the outstretched hand, are common accidents produced by indirect violence. The ribs also may be broken by indirect violence, as when the chest is crushed antero-posteriorly and the bones give way near their angles. In fractures by indirect violence the soft parts do not suffer by the violence causing the fracture, but they may be injured by displacement of the fragments.

In fractures by *muscular action* the bone is broken by "traction" or "tearing." The sudden and violent contraction of a muscle may tear off an epiphysis, such as the head of the fibula, the anterior superior iliac spine, or the coronoid process of the ulna; or a bony process may be separated, as for example the tuberosity of the os calcis, the coracoid process of the scapula, or the greater tuberosity of the humerus. Long bones also may be broken by muscular action. The clavicle has snapped across during the act of swinging a stick, the

humerus in throwing a stone, and the femur when a kick has missed its object. Fractures of ribs have occurred during fits of coughing and in the violent efforts of parturition.

Before concluding that a given fracture is the result of muscular action, it is necessary to exclude the presence of any of the diseased conditions that lead to pathological fracture.

Although the force acting upon the bone is the primary factor in the production of fractures, there are certain subsidiary factors to be considered. Thus the age of the patient is of importance. During infancy and early childhood, fractures are less common than at any other period of life, and are usually transverse, incomplete, and of the nature of bends. During adult life, especially between the ages of thirty and forty, the frequency of fractures reaches its maximum. In aged persons, although the bones become more brittle by the marrow spaces in their interior becoming larger and filled with fat, fractures are less frequent, doubtless because the old are less exposed to such violence as is likely to produce fracture.

Males, from the nature of their occupations and recreations, sustain fractures more frequently than do females; in old age, however, fractures are more common in women than in men.

Clinical Varieties of Fractures.—The most important subdivision of fractures is that into simple and compound.

In a *simple* or subcutaneous fracture there is no communication, directly or indirectly, between the broken ends of the bone and the surface of the skin. In a *compound* or open fracture, on the other hand, such a communication exists, and, by furnishing a means of entrance for bacteria, may add materially to the gravity of the injury.

A simple fracture may be complicated by the existence of a wound of the soft parts, which, however, does not communicate with the broken bone.

Fractures, whether simple or compound, fall into other clinical groups, according to (1) the degree of damage done to the bone, (2) the direction of the break, and (3) the relative position of the fragments.

(1) *According to the Degree of Damage done to the Bone.*—A fracture may be incomplete, for example, in *greenstick fractures* which occur only in young persons—usually below the age of twelve—while the bones are still soft and flexible. They result from forcible bending of the bone, the osseous tissue on the convexity of the curve giving way, while that on

the concavity is compressed. The clavicle and the bones of the forearm are those most frequently the seat of greenstick fracture (Fig. 160). *Fissures* occur on the flat bones of the skull, the pelvic

bones, and the scapula ; or in association with other fractures in long bones (Fig. 111), when they often run into joint surfaces ; clinically they can only be recognised when compound. *Depressions* or indentations are most common in the bones of the skull.

The bone at the seat of fracture may be broken into several pieces, constituting a *comminuted* fracture. This usually results from severe degrees of direct violence, such as are sustained in railway or machinery accidents, and in gun-shot injuries.

Sub-periosteal fractures are those in which, although the bone is completely broken across, the periosteum remains intact. These are especially common in children, and as the thick periosteum prevents displacement, the existence of a fracture may be overlooked, even in such a large bone as the femur.

A bone may be broken at several places, constituting a *multiple* fracture (Fig. 109).

Separation of bony processes, such as the coracoid process, the epicondyle of the humerus, or the tuberosity of the os calcis, may result from muscular action or from direct violence. *Separation of epiphyses* will be considered later.

(2) According to the Direction of the Break.—Transverse



FIG. 109. — Multiple Fracture of Tibia and Oblique Fracture of Fibula, the result of a cable-car accident.



FIG. 110. — Spiral Fracture of Humerus, caused by torsion of the upper arm in an old woman.

fractures are those in which the bone gives way more or less exactly at right angles to its long axis. These usually result from direct violence or from end-to-end pressure.

Longitudinal fractures extending the greater part of the length of a long bone are exceedingly rare. *Oblique* fractures are common, and result usually from indirect violence, bending, or torsion (Figs. 111 and 112). *Spiral* fractures result from forcible torsion of a long bone, and are met with most frequently in the tibia, femur, and humerus (Fig. 110).

(3) *According to the Relative Position of the Fragments.*—The bone may be completely broken across, yet its ends remain in apposition, in which case there is said to be *no displacement*. There may be an *angular* displacement—for example, in greenstick fracture. In transverse fractures of the patella or of the olecranon there is often *distraction* or pulling apart of the fragments (Fig. 151). The broken ends, especially in oblique fractures, may *override* one another, and so give rise to shortening of the limb. Where one



FIG. 111.—Oblique Fracture of Upper Third of Tibia with Fissuring of Lower Fragment. Limb run over by a railway waggon.



FIG. 112.—Showing (1) Oblique Fracture of Tibia; (2) Oblique Fracture with partial Separation of Epiphysis of Upper End of Fibula; (3) Incomplete Fracture of Fibula in Upper Third. Result of railway accident. Boy æt. 16.

fragment is acted upon by powerful muscles, a *rotatory* displacement may take place, as in fracture of the radius above the insertion of the pronator radii teres, or of the femur just below the small trochanter. The fragments may be *depressed*, as in the flat bones of the skull or the nasal bones. At the can-

cellated ends of long bones, particularly the upper end of the femur and humerus, and the lower end of the radius, it is not uncommon for one fragment to be *impacted* or wedged into the substance of the other (Fig. 138).

Causes of Displacement.—The factors which influence displacement are chiefly mechanical in their action. Thus the direction and nature of the fracture play an important part. Transverse fractures with roughly serrated ends are less liable to displacement than those which are oblique with smooth surfaces. The direction of the causative force also is a dominant factor in determining the direction in which one or both of the fragments will be displaced. Gravity, acting chiefly upon the distal fragment, also plays a part in determining the displacement, for example, in fractures of the thigh or of the bones of the leg, where the lower segment of the limb rolls outwards, and in fractures of the shaft of the clavicle, where the weight of the arm carries the shoulder downwards, forwards, and inwards. After the break has taken place and the force has ceased to act, displacement may be produced by rough handling on the part of those who render first aid, the careless or improper application of splints or bandages, or by the weight of the bed-clothes.

In certain situations the contraction of unopposed, or of unequally opposed, groups of muscles plays a part in determining displacement. For example, in fracture immediately below the lesser trochanter of the femur, the ilio-psoas tends to tilt the upper fragment forward and outward; in supra-condylar fracture of the femur, the muscles of the calf pull the lower fragment back towards the popliteal space; and in fracture of the humerus above the deltoid insertion, the muscles inserted into the bicipital groove adduct the upper fragment.

Clinical Features of Simple Fractures.—In the first place, the *history of the accident* should be investigated, attention being paid to the nature of the violence—whether a blow, a twist, a wrench, or a crush, and whether the violence was directly or indirectly applied. The degree of the violence may often be judged approximately from the instrument inflicting it—whether, for example, a fist, a stick, a cart wheel, or a piece of heavy machinery. The position of the limb at the time of the injury; whether the muscles were braced to meet the blow or were lax and taken unawares; and the patient's sensations at the moment, such as his feeling something snap or tear, may all furnish information useful for purposes of diagnosis.

Signs of Fracture.—The most characteristic signs of fracture are unnatural mobility, deformity, and crepitus.

Unnatural mobility—that is, movement between two segments of a limb at a place where movement does not normally occur—may be evident when the patient makes attempts to use his limb, or may only be elicited when the fragments are seized and moved in opposite directions. *Deformity*, or the part being “out of drawing” in comparison with the normal side, varies with the site and direction of the break, and depends upon the degree of displacement of the fragments. *Crepitus* is the name applied to the peculiar grating or clicking which may be heard or felt when the fractured surfaces are rubbed against one another.

The presence of these three signs in association is sufficient to prove the existence of a fracture, but the absence of one or more of them does not negative this diagnosis. There are certain fallacies to be guarded against. For example, a fracture may exist, and yet unnatural mobility may not be present because the bones are impacted into one another, or because the fracture is an incomplete one. Again, the extreme tension of the swollen soft tissues overlying the fracture may prevent the recognition of movement between the fragments. Deformity also may be absent—as, for instance, when there is no displacement of the fragments, or when only one of two parallel bones is broken, as in the leg or forearm. Similarly, crepitus may be absent when impaction exists, when the fragments completely override one another, or are separated by an interval, or when soft tissues, such as torn periosteum or muscle, are interposed between them. A sensation simulating crepitus may be felt on palpating a part into which blood has been extravasated, or which is the seat of subcutaneous emphysema. The creaking which accompanies movement in certain forms of teno-synovitis and chronic joint disease, and the rubbing of the dislocated end of a bone against the tissues amongst which it lies, may also be mistaken for the crepitus of fracture.

It is not advisable to be very diligent in eliciting these signs, partly because of the pain caused by the manipulations, and partly because vigorous handling may do harm by undoing impaction, or by producing displacement which does not already exist, or by converting a simple into a compound fracture.

It is often necessary for purposes of diagnosis to administer a general anæsthetic, particularly in injuries of deeply placed bones and in the vicinity of joints. Before doing so, the appliances necessary for the treatment of the injury should be

made ready, in order that the fracture may be reduced and set before the patient regains consciousness.

Radiography in the Diagnosis of Fractures.—While radiography is of inestimable value in the diagnosis of many fractures and other injuries, particularly in the vicinity of joints, the student is warned against relying too implicitly on the evidence it seems to afford.

A radiogram is not a photograph of the object exposed to the X-rays, but merely a picture of its shadow. As the rays emanate from a single point in the vacuum tube, and as they are not, like the sun's rays, approximately parallel, the shadows they cast are necessarily distorted. Hence, in interpreting a radiogram, it is necessary to know the relative positions of the point from which the rays proceed, the object exposed, and the photographic plate on which the shadow is registered. The least distortion takes place when the object is in contact with the plate, and the shadow of that part of the object which lies perpendicularly under the light is less distorted than that of the parts lying outside the perpendicular. The light and the plate remaining constant, the amount of distortion varies directly with the distance between the object and the plate.

To ensure accuracy in the diagnosis of fracture by the X-rays, it is often necessary to take two views of the limb—one in the sagittal and the other in the coronal plane. By the use of the fluorescent screen, the best positions from which to obtain a clear impression of the fracture may be determined before the radiograms are taken.

Imperfect technique and faulty interpretation of the pictures obtained lead to certain fallacies. In young subjects, for example, epiphysial lines may be mistaken for fractures, or the ossifying centres of epiphyses for separated fragments of bone. The os trigonum tarsi has been mistaken for a fracture of the astragalus. In the vicinity of joints the bones may be crossed by pale bands, due to the rays traversing the cavity of the joint. In this way fracture of the olecranon or of the clavicle may be simulated. The neck of the femur may appear to be fractured if a foreshortened view is taken.

It is possible, on the other hand, to overlook a fracture—for example, if there is no displacement, or if the line of fracture is crossed by the shadow of an adjacent bone. In deeply placed bones such as those about the hip, or in bones related to dense, solid viscera—for example, ribs, sternum, or vertebræ—it is sometimes difficult to obtain conclusive evidence of fracture in a radiogram.

It is to be borne in mind also, and especially from the medico-legal point of view, that, as early callus does not cast a shadow in a radiogram, the appearance of fracture may persist long after union has taken place. The disturbed perspective produced by divergence of the rays may cause the fragments of a united fracture to appear displaced, although in reality they are in good position. If the limb and the plate are not parallel, the bones may appear to be distorted, and errors in diagnosis may in this way arise. In this relation it should be mentioned, that perfect apposition of the fragments and anatomically accurate restoration of the outline of the bones are not essential to a good functional result.

As most of the remaining signs are common to all the lesions from which fractures have to be distinguished, their diagnostic value must be carefully weighed.

Interference with Function.—As a rule, a broken bone is incapable of performing its normal function as a lever or weight-bearer; but when a fracture is incomplete, when the fragments are impacted, or when only one of two parallel bones is broken, this does not necessarily follow. It is no uncommon experience to find a patient walk into hospital with an impacted fracture of the neck of the femur or a complete fracture of the fibula; or to be able to pronate and supinate the forearm with a greenstick fracture of the radius or a complete fracture of the ulna.

Pain.—Three forms of pain may be present in fractures: pain independent of movement or pressure; pain induced by movement of the limb; and pain elicited on pressure or "tenderness." In injuries by direct violence, pain independent of movement and pressure is never diagnostic of fracture, as it may be due to bruising or tearing of soft tissues. In injuries resulting from indirect violence, however, pain localised to a spot at some distance from the point of impact is strongly suggestive of fracture—as, for example, when a patient complains of pain over the clavicle after a fall on the hand, or over the upper end of the fibula after a twist of the ankle. Pain elicited by attempts to move the damaged part, or by applying pressure over the seat of injury, is more significant of fracture. Pain elicited at a particular point on pressing the bone at a distance, "pain on distal pressure,"—for example, pain at the lower end of the fibula on pressing near its neck, or at the angle of a rib on pressing near the sternum—is a valuable diagnostic sign of fracture. When nerve-trunks are implicated

in the vicinity of a fracture, pain is often referred along the course of their distribution.

Localised swelling comes on rapidly, and is due to displacement of the fragments and effusion of blood.

Discoloration accompanies the swelling, and is often widespread, especially in bones near the surface and when the tension is great. It is not uncommon to find over the ecchymosed area, especially over the shin-bone, large dark blebs containing blood-stained serum. In fractures of deep-seated bones, discoloration may only show on the surface after some days, and at some distance from the break.

Alterations in the relative position of *bony landmarks* are valuable diagnostic guides. Alteration in the *length* of the limb, usually in the direction of shortening, is also an important sign. Before drawing deductions, care must be taken to place both limbs in the same position and to determine accurately the fixed points for measurement, and also to ascertain if the limbs were previously normal.

Shock is seldom a prominent symptom in uncomplicated fractures, although in old and enfeebled patients it may be serious and even fatal. During the first two or three days after a fracture there is almost invariably some degree of traumatic fever, indicated by a rise of temperature to 99° or 100° F. (Fig. 12).

Complications.—*Injuries to large arteries* are not common in simple fractures. The femoral, popliteal, and tibial arteries, however, are liable to be compressed, punctured, or torn across in fractures of the bones with which they lie in close contact. Thrombosis, aneurysm, or gangrene of the limb may follow such injuries. If large *veins* are injured, thrombosis may occur, and be followed by pulmonary embolism.

Injuries to nerve-trunks are comparatively common, especially in fractures of the upper arm, where the musculo-spiral, ulnar, or other branches of the brachial plexus are liable to suffer.

The nerves may be implicated at the time of the injury, being compressed, bruised, lacerated, or completely torn across by broken fragments, or they may be involved later by becoming compressed by callus. The symptoms depend upon the degree of damage sustained by the nerve, and vary from partial and temporary interference with sensation and motion to complete and permanent abrogation of function.

Suppuration and necrosis are exceedingly rare sequelæ of simple fractures. *Fat embolism* sometimes occurs, and fat globules are found in the urine. In persons addicted to alcohol,

delirium tremens is a not infrequent accompaniment of fractures which confine them to bed.

Prognosis in Simple Fractures.—Danger to life in simple fractures depends chiefly on the occurrence of complications. In old people, when the injury necessitates long and continuous lying on the back, bronchitis, hypostatic pneumonia, and bed-sores are prone to occur. Gradually increasing debility and mental deterioration also cause anxiety in these cases. Fractures complicated with injury to internal organs, and fractures in which gangrene threatens, are, of course, of grave import.

The prognosis as regards the function of the limb should always be guarded, even in simple fractures. Incidental complications are liable to arise, delaying recovery and preventing a satisfactory result, and these not only lead to disappointment, but may even form a ground for actions for malpraxis.

The character, direction, and extent of the fracture influence the prognosis, the best results usually following single and transverse breaks, while those which are multiple, comminuted, or oblique unite less rapidly and less satisfactorily.

Fibrous union is a common result in fractures of the neck of the femur in old people and in certain other fractures, such as fracture of the patella, of the olecranon, coronoid and coracoid processes, and although this does not necessarily involve any serious interference with function, the patient should always be warned of the possibility.

Impairment of growth and eventual shortening of the limb may result from involvement of an epiphysial junction (Fig. 142).

Stiffness of joints is liable to follow fractures implicating articular surfaces, or it may result from chronic arthritic changes following upon the injury.

Osseous ankylosis is not a common sequel of simple fractures, but locking of joints from the mechanical impediment produced by the union of imperfectly reduced fragments, or from masses of callus, is not uncommon, especially in the region of the elbow.

Wasting of the muscles and œdema of the limb often delay the complete restoration of function. Delayed union, want of union, and the formation of false-joints will be referred to later.

Treatment.—The treatment of a fracture should be commenced as soon after the accident as possible, before the muscles become contracted and hold the fragments in abnormal

positions, and before blood and serum are effused into the tissues and adhesions form.

Every care must be taken during the transport of the patient that no further damage is done to the injured limb. To this end the part must be secured in the best form of extemporised splint that the ingenuity of the surgeon and the surroundings of the patient can furnish, the apparatus being so designed as to control not only the broken fragments, but also the joints above and below the fracture.

When the ordinary method of removing the clothes involves any risk of unduly moving the injured part, they should be slit open along the seams.

The patient should be placed on a firm straw, horse-hair, or spring mattress, stiffened in the case of fractures of the spine, pelvis, or lower limbs, by strong wooden fracture-boards inserted between the mattress and the frame of the bed. Special mattresses constructed in four pieces, to facilitate the nursing of the patient, are sometimes used. Feather beds are to be avoided.

In many cases, particularly in very muscular subjects, in restless alcoholic patients, and in those who do not bear pain well, a general anæsthetic is a valuable aid to the rapid and accurate setting of a fracture, as well as a means of rendering the diagnosis more certain.

The procedure popularly known as "setting a fracture" consists in restoring the displaced parts to their normal position as nearly as possible, and is spoken of technically as the *reduction* of the fracture.

The Reduction of the Fracture.—In some cases the displacement may be completely overcome by relaxing the muscles acting upon the fragments. In most cases, however, it is necessary, after relaxing the muscles, to employ *extension*, by making forcible but steady traction on the distal fragment, while *counter-extension* is exerted on the proximal one, either by an assistant pulling upon that portion of the limb, or by the weight of the patient's body. The fragments having been freed, and any shortening of the limb corrected in this way, the broken ends are moulded into position—a process termed *coaptation*.

The reduction of a recent greenstick fracture consists in forcibly straightening the bend in the bone, and in some cases it is necessary to render the fracture complete before this can be accomplished.

In certain cases of impacted fracture which will be specified later, it is not advisable to undo the impaction.

In selecting a means of retaining a fracture in position after its reduction, the various factors which tend to bring about re-displacement must be taken into consideration, and appropriate measures adopted to counteract each of these. Thus it may be that the fragments, being oblique, tend to glide past one another; that powerful muscles inserted into one of the fragments pull it away from its neighbour; that the weight of the distal portion of the limb causes it to fall in a particular direction in obedience to gravity; or that certain movements on the part of the patient determine displacement.

In addition to retaining the broken ends of the bone in apposition, the after-treatment of a fracture involves the taking of steps to promote the absorption of effused blood and serum, to maintain the circulation through the injured parts, and to favour the repair of damaged muscles and other soft tissues. Means must also be taken to maintain the functional activity of the muscles of the damaged area, to prevent the formation of adhesions in joints and tendon sheaths, and generally to restore the function of the injured part.

Practical Means of Effecting Retention—By Position.—It is often found that only in one particular position can the fragments be made to meet and remain in apposition—for example, the completely supine position of the forearm in fracture of the radius just above the insertion of the pronator radii teres. Again, in certain cases it is only by relaxing particular groups of muscles that the displacement can be undone—as, for instance, in fracture of the bones of the leg, or of the femur immediately above the condyles, where flexion of the knee, by relaxing the calf muscles, permits of reduction.

Massage and Movement in the Treatment of Fractures.—Until within recent years, fractures were invariably treated by complete immobilisation of the injured limb in a splint or other form of rigid apparatus, until firm osseous union had taken place. The result of the prolonged fixation of the limb was that in many cases the muscles underwent atrophy, adhesions formed in joints and tendon sheaths, the restoration of function was much delayed, and in some cases permanent stiffness resulted.

Lucas-Championnière, in 1886, was the first to point out that a slight degree of movement between the ends of a fractured bone favours their union by promoting the formation of callus, and to advocate the treatment of fractures by massage and movement, and the discarding of splints and other retentive appliances.

In the majority of cases the massage and movement are commenced at once, but circumstances may necessitate its being deferred for a few days. The measures adopted vary according to the seat and nature of the fracture, but in general terms it may be stated that after the fracture has been reduced, the ends of the broken bone are retained in position by the hands of an assistant, and gentle massage is applied by the surgeon or by a trained masseur. The lubricant may either be a powder composed of equal parts of talc and boracic acid, or an oily substance such as olive oil or lanolin. The rubbing should never cause pain, but, on the contrary, should relieve any pain that exists, as well as the muscular spasm which is one of the most important causes of pain in recent fractures. The parts on the proximal side of the injured area are first gently stroked upwards to empty the veins and lymphatics, and to disperse the effused blood and serum. The process is then applied to the swollen area, and gradually extended down over the seat of the fracture and into the parts beyond. In this way the circulation through the damaged segment of the limb is improved, the veins are emptied of blood, the removal of effused fluid is stimulated, and the muscular irritability allayed. The joints of the limb are gently moved, and the patient is encouraged to contract the muscles voluntarily, care being taken all the while that the broken ends of the bone are not displaced. After the rubbing has been continued for from fifteen to twenty minutes, the limb is placed in a comfortable position, and retained there by pillows, sand-bags, or, if found more convenient, by a light form of splint.

The massage is repeated once each day ; the sittings last from ten to fifteen minutes. The sequence should be, first, massage ; second, passive movement ; and third, active movement. At first massage predominates, and more passive than active movement ; gradually massage is lessened and movements are increased, active movements ultimately preponderating.

The value of this procedure is greatest in fractures in the vicinity of joints, particularly the elbow, ankle, wrist, and knee. Not only is pain diminished, the formation of bony callus promoted and union thereby hastened, but the prolonged crippling stiffness which so often follows immobilisation in splints is avoided. The risk of redisplacement of fragments is only to be feared in oblique fractures in the shafts of long bones, such as the humerus, femur, or bones of the leg ; but even in these situations, by keeping on the extension and carefully fixing the broken ends while the massage and move-

ments are being carried on, any such ill-effects can usually be obviated. Want of union, so far from being a risk attending this method of treatment, is less liable to occur, if ordinary precautions are taken, than when the limb is immobilised throughout the treatment.

Splints and other Appliances.—The less complicated and specialised splints are, the better. The appropriate splints for individual fractures and the method of applying them will be described later; but it may here be said that the general principle is that when dealing with a part where there is a single bone, as the thigh or upper arm, the splint should be applied in the form of a *ferrule* to surround the break; while in situations where there are two parallel bones, as in the forearm and leg, the splint

should take the form of a *box* (Fig. 113).

Simple wooden splints of plain deal board or yellow pine, sawn to the appropriate length and width; or *Gooch's splinting*, which consists of long strips of soft wood, glued to a backing of wash-leather, are the most useful materials. Gooch's splinting has the special advantage that when applied with the leather side next the limb it encircles the part as a ferrule; while it remains rigid when the wooden side is turned

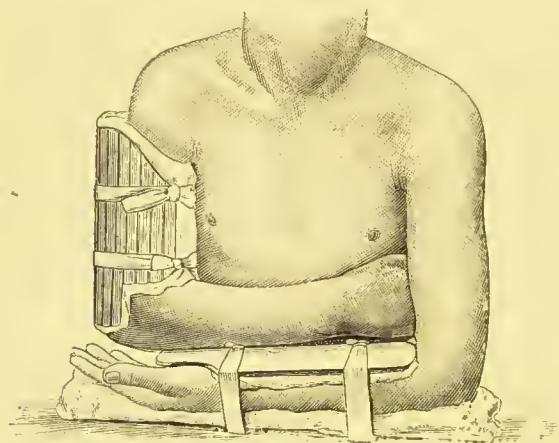


FIG. 113.—Gooch Splint applied as a "Ferrule" on Right Upper Arm, as a "Box" on Left Forearm.

towards the skin (Fig. 113). Perforated sheet lead or tin, stiff wire netting, and hoop iron also form useful splints.

When it is desirable that the splint should take the shape of the part accurately, a plastic material may be employed. Perhaps the most convenient is *poroplastic felt*, which consists of strong felt saturated with resin. When heated before a fire or placed in boiling water, it becomes quite plastic and may be accurately moulded to any part, and on cooling it again becomes rigid. The splint should be cut from a carefully fitted paper pattern. Millboard, leather, or gutta-percha softened in hot water, and moulded to the part, may also be employed.

In conditions where treatment by massage and movement is impracticable, and where movable splints are inconvenient, splints of *plaster of Paris*, starch, or *water-glass* are sometimes used, especially in the treatment of fractures of the leg. When employed in the form of an immovable case, they are open to certain objections—for example, if applied immediately after the accident they are apt to become too tight if swelling occurs; and if applied while swelling is still present, they become slack when this subsides, so that displacement is liable to occur.

When it is desired to enclose the limb in a plaster case, coarse muslin

bandages, three yards long, and charged with the finest quality of thoroughly dried plaster of Paris, are employed. The "acetie plaster bandages" sold in the shops set most quickly and firmly. A boracic lint bandage is evenly applied next the skin, and the bony prominences are specially padded. The plaster bandage is then placed in cold water till air bubbles cease to escape, by which time it is thoroughly saturated, and, after the excess of water is squeezed out, is applied in the usual way from below upward. From two to four plies of the bandage are required. In the course of half an hour the plaster should be thoroughly set. To facilitate the removal of a plaster ease the limb should be immersed for a short time in tepid water.

Croft's splint, or some modification of it, is perhaps the best form of movable plaster splint. It is made by accurately shaping *two* pieces of thoroughly shrunk house-flannel to *each* side of the limb, and immersing one of each pair in a solution of plaster of Paris of the consistence of thin cream till the flannel is thoroughly impregnated. The dry pieces are placed next the skin, with the saturated pieces over them, and a coarse gauze bandage is then applied to fix them in position. After the plaster has set, and it is desired to remove the splint for the purpose of employing massage, the gauze bandage is cut along the front of the limb, and the splint opened out on the hinge formed by the posterior turns of the bandage.

A most convenient and efficient splint is made by moulding two pieces of poroplastic felt to the sides of the limb, and fixing them in position with an elastic webbing bandage.

Padding is an essential adjunct to all forms of splints. The whole part enclosed in the splint must be covered with a thick layer of soft and elastic material, such as cotton wool or lint. All hollows should be filled up, and all bony projections specially protected by rings of wadding so arranged as to take the pressure off the prominent point and distribute it on the surrounding parts. Opposing skin surfaces must always be separated by a layer of cotton wool or boracic lint. A bandage should never be applied to the limb underneath the splints and pads, as congestion or even gangrene may be induced thereby.

Operative Treatment of Simple Fractures.—In certain cases it is found impossible to bring the fragments into accurate apposition or to retain them there. This may be due to the obliquity of the fracture, as, for example, in the shaft of the femur or in the bones of the leg; to the interlocking of fragments, as occurs frequently in epiphysial separations; to the traction of powerful muscles on one of the fragments, as in fracture of the patella or olecranon; or to the interposition of soft tissues between the broken ends. Under such circumstances it is necessary to expose the fracture by operation, and after reducing it, to fix the fragments together by wires, pegs, plates, or screws. Operative interference is usually delayed till about a week after the injury, by which time the effect of other measures will have been estimated, and accurate information obtained by means of the X-rays regarding the nature of the lesion and the position of the fragments. Such

operations, however, are not to be undertaken lightly, as they are often difficult, and if septic infection takes place the results may be disastrous. Arbuthnot Lane and others advocate a more general resort to operative measures, even in simple and uncomplicated fractures.

Both before and after operations, massage and movement are to be carried out as already described.

COMPOUND FRACTURES

The characteristic feature of a compound fracture is the existence of an open wound leading down to the break in the bone, and it is the presence of the wound which, by providing a means of entrance for bacteria, dominates the whole aspect of the case. The wound may vary in size from a mere puncture to an extensive ragged tear of all the soft parts.

A fracture may be rendered compound *from without*, the soft parts being damaged by the object which breaks the bone—as, for example, a cart wheel, a piece of machinery, or a bullet. Sloughing of soft parts resulting from the pressure of improperly applied splints, also, may convert a simple into a compound fracture. On the other hand, a simple fracture may be rendered compound *from within*—for example, a sharp fragment of bone may penetrate the skin, or the skin may slough as a result of extreme tension from effused blood.

As a rule, it is easy to recognise that the fracture is compound, as the bone can either be seen or felt through the wound. When any doubt exists as to whether or not a wound communicates with the bone, it is safer to enlarge it by incision than to assume that the fracture is simple.

The *prognosis* depends on the success which attends the efforts to make and to keep the wound aseptic, as well as on the extent of damage to the tissues. When sepsis ensues, fragments of bone may undergo necrosis and lead to the formation of sinuses, and union is usually attended with excessive and irregular callus formation (Fig. 118).

Treatment.—The leading indication is to ensure asepsis. Even in the case of small punctured wounds caused by a pointed fragment coming through the skin, it is never wise to assume that the wound is not infected. It is much safer to enlarge such a wound, pare away the bruised edges, and disinfect the raw surfaces.

In cases of extensive laceration of the soft parts, all soiled, bruised, or torn portions of tissue should be clipped away with

scissors, blood-clots removed, and the bleeding arrested by forcipressure or ligature. If there is any reason to believe that the wound is infected, any fragments of bone completely separated from the periosteum should be removed. The wound should then be washed out with sterilised salt solution. On the whole, it is safer not to attempt to obtain primary union by completely closing such wounds, but rather to drain or pack them. To increase the local leucocytosis and so check the spread of infection, a Bier's constricting bandage should be applied.

In other respects the treatment of compound fractures is carried out on the same lines as in simple fractures, provision being made for dressing the wound, without disturbance of the bones. Massage and movement should be commenced after the wound is healed and the condition has become analogous to a simple fracture.

Question of Amputation in Compound Fractures.—Before deciding to perform primary amputation of a limb for compound fracture, the surgeon must satisfy himself (1) that the attainment of asepsis is impossible; (2) that the soft parts are so widely and so grossly damaged that their recovery is improbable; (3) that the vascular and nervous supply of the parts beyond has been rendered insufficient by destruction of the main blood-vessels and nerve-trunks; (4) that the bones have been so shattered as to be beyond repair; and (5) that the limb, even if healing takes place, will be less useful than the stump resulting after amputation.

In attempting to save the limb of a young subject, it is justifiable to run risks which would not be permissible in the case of an older person. To save an upper limb, also, risks may be run which would not be justifiable in the case of a lower limb, because, while a serviceable artificial leg can readily be procured, any portion of the natural hand or arm is infinitely more useful than the best substitute which the instrument-maker can contrive. The risk involved in attempting to save a limb should always be explained to the patient or his friends, in order that they may share the responsibility in case of failure.

Whether or not the amputation should be performed at once, depends upon the general condition of the patient. If the injury is a severe one, and attended with a profound degree of shock, it is better to wait for twenty-four or forty-eight hours. Meanwhile the wound is thoroughly purified, and the limb wrapped in an antiseptic dressing. Means are taken to

counteract shock and to maintain the patient's strength, and evidence of septic infection or of hæmorrhage is carefully watched for. When the shock has passed off and the patient is able to stand the operation, it is then performed under more favourable auspices. Clinical experience has proved that by this means the mortality of primary amputations may be materially diminished, especially in injuries necessitating removal of an entire limb.

Having decided to amputate, it is important to avoid having bruised, torn, or separated tissues in the flaps, as these are liable to slough or to become the seat of septic infection. In this connection it should be borne in mind that the damage to soft tissues is always wider in extent than appears from external examination.

Amputation may be called for later because of spreading septic processes, osteomyelitis, or gangrene of the limb; to prevent exhaustion from prolonged suppuration and septic absorption; or on account of secondary hæmorrhage.

SEPARATION OF EPIPHYSES

It is only within late years that the subject of the separation of epiphyses (or, as these injuries are sometimes called, *diastases*¹) has received its due share of attention, and the use of the X-rays has added greatly to our knowledge of these lesions.

It is useful to remember that in the upper extremity the epiphyses in the regions of the shoulder and wrist, and, in the lower extremity, those in the region of the knee, are the latest to unite; and that it is in these situations that growth in length of the bone goes on longest and most actively. Injuries of these epiphyses, therefore, are most liable to interfere with the growth of the limb.

An epiphysis is nourished from the articular arteries and through the vessels of the periosteum.

Pathological Separation of Epiphyses.—There are certain pathological conditions, such as rickets, scurvy, congenital syphilis, tubercle, suppurative conditions, and tumour growths, which render separation of epiphyses liable to occur from injuries altogether insufficient to produce such lesions under normal conditions.

1. The term "diastasis" has been employed in different senses by different writers.

Traumatic Separations.¹—Speaking generally, it may be said that injuries which in an adult would be liable to produce dislocation, are in a young person more apt to cause separation of an epiphysis. Indirect violence, especially when exerted in such a way as to combine traction with torsion, for example when the leg is caught in the spokes of a carriage wheel, is the commonest cause of epiphysial separation. Direct violence is a much less frequent cause. Muscular action occasionally produces separation of such epiphyses as the anterior superior iliac spine, the small trochanter of the femur, or the upper fibular epiphysis.

It would appear that the majority of separations take place between the eleventh and the eighteenth years, chiefly because during this period the injuries liable to produce such lesions are most prone to occur. They do not occur after twenty-five, because by that time all the epiphyses have united. In females this form of injury is rare, and almost invariably occurs before puberty.

The following are the most common seats of separation in the order of their frequency:—(1) The lower end of the femur; (2) the lower end of the radius; (3) the upper end of the humerus; (4) the lower end of the humerus; (5) the lower end of the tibia; and (6) the upper end of the tibia.

Morbid Anatomy.—In a true separation the epiphysial cartilage remains attached to the epiphysis. As a rule the epiphysis is not completely separated from the diaphysis, the common lesion being a separation along part of the epiphysial line, with a fracture running into the diaphysis (Fig. 115). It is not uncommon for more than one epiphysis to be separated by the same accident—for example, the lower end of the femur and the upper ends of the tibia and fibula. Epiphysial separations, like fractures, may be *simple* or *compound*. Incomplete separations are liable to be overlooked at the time of the accident, but there is reason to believe that they may form the starting-point of various diseases of bones and joints. Strain of the epiphysial junction—the *juxta-epiphysial strain* of Ollier—is a common injury in young children.

Clinical Features.—The symptoms simulate those of dislocation rather than of fracture. Thus, *unnatural mobility* at an epiphysial junction may closely resemble movement at the adjacent joint, especially when the epiphysis is an intra-capsular

¹ We desire here to acknowledge our indebtedness to Mr. John Poland's work on *Traumatic Separation of the Epiphyses*.

one. The relationship of the bony points, however, serves to indicate the nature of the lesion. The degree of *deformity*



FIG. 114.—Complete Separation of Epiphysis.



FIG. 115.—Partial Separation of Epiphysis, with Fracture running into Diaphysis.

is often slight, because the transverse direction of the lesion, the breadth of the separated surfaces, and the firmness of the



FIG. 116.—Partial Separation with Fracture of Epiphysis.



FIG. 117.—Complete Separation with Fracture of Epiphysis.

periosteal attachment along the epiphysial line prevent displacement. In many cases a distinct, rounded, smooth, and regular ridge, caused by the projection of the diaphysis, can be felt. The peculiar "muffled" nature of the *crepitus* is one of the most characteristic signs. The older the patient, and the further ossification has progressed, the more does the *crepitus* resemble that of fracture.

Of the subsidiary signs, *loss of power* in the limb is one of the most constant; indeed, in young children it is sometimes the first, and may be the only sign which attracts attention. *Pain* and *tenderness* along the epiphysial line are valuable signs, particularly when the lesion is due to indirect or muscular violence and there is no bruising of soft parts. Localised *swelling*, accompanied by *ecchymosis*, is often marked; and the adjacent joint may be distended with fluid.

As distinguishing this injury from a dislocation, it may be noted that in epiphysial separation there is no snap felt when the deformity is reduced, the tendency to re-displacement is greater, and the amount of relief given by reduction less than in dislocation.

The use of the Röntgen rays at once establishes the diagnosis.

Prognosis and Results.—In the great majority of cases union takes place satisfactorily by the formation of callus in the spongy tissue of the diaphysis and on the deep surface of the periosteum. In spite of the favourable nature of the prognosis in general, however, the friends of the patient should be warned that a completely satisfactory result cannot always be relied upon.

Deformity, and impairment of movement at the adjacent joint, may result from imperfect reduction, from exuberant callus, or from adhesions. Arrest of growth of the bone in length is a rare sequel, and when it occurs, it is due, not to premature union of the epiphysis with the shaft, but to diminished action at the ossifying junction.

When the growth of one of the bones of the leg or forearm is arrested after separation of its epiphysis while the other bone continues to grow, the foot or hand is deviated towards the side of the shorter bone.

Treatment.—The general principles which govern the treatment of fractures apply equally to epiphysial separations, and the special points will be described with the individual lesions.

REPAIR OF INJURIES OF BONE

In a *simple fracture*, the vessels of the periosteum and the marrow being torn at the same time as the bone is broken, a blood-clot forms around and between the fragments. This clot is soon permeated by newly formed blood-vessels, and by leucocytes and fibroblasts, the latter being derived from proliferation of the cells of the marrow and periosteum. The granulation tissue thus formed resembles in every particular that described in the repair of other tissues, except that the fibroblasts, being the offspring of cells which normally form bone, assume the functions of *osteoblasts*, and proceed to the formation of bone. The new bone may be formed either by a direct conversion of the fibrous tissue into osseous tissue, the osteoblasts arranging themselves concentrically in the recesses of the capillary loops, and secreting a homogeneous matrix in which lime-salts are speedily deposited; or there may be an intermediate stage of cartilage formation, especially in young subjects, and in cases where the fragments are not completely immobilised. The newly formed bone is at first arranged in little masses or in the form of rods which unite with each other to form a network of spongy bone, the meshes of which contain marrow.

The reparative material, consisting of granulation tissue in the process of conversion into bone, is called *callus*, on account of its hard and unyielding character. In a fracture of a long bone, that which surrounds the fragments is called the *external* or *ensheathing callus*, and may be likened to the mass of solder which surrounds the junction of pipes in plumber-work; that which occupies the position of the medullary canal is called the *internal* or *medullary callus*; and that which intervenes between the fragments and maintains the continuity of the cortical compact tissue of the shaft is called the *intermediate callus*. This intermediate callus is the only permanent portion of the reparative material, the external and internal callus being only temporary, and being largely reabsorbed through the agency of giant cells.

Detached fragments or splinters of bone may be absorbed, or they may be included in the callus and ultimately become incorporated in the new bone that bridges the gap.

All surplus bone is removed, the medullary canal is re-formed, the young spongy bone of the intermediate callus becomes more and more compact, and thus the original architectural arrangement of the bone may be faithfully reproduced.

The amount of callus produced in the repair of a given fracture is greater when movement is permitted between the broken ends. It is also influenced by the character of the bone involved, being less in bones entirely ossified in membrane, such as the flat bones of the skull, than in those primarily ossified in cartilage.

If the fragments are widely separated from one another, or if some tissue, such as muscle, intervenes between them, callus may not be able to bring about a bony union between the fragments, and *non-union* results.

Bones divided in the course of an operation, for example in osteotomy for knock-knee, or wedge-shaped resection for bow-leg, are repaired by the same process as fractures.

A *compound fracture*, if not infected by bacteria, heals in the same way as a simple one. Should infection ensue, however, the reparative process is delayed, detached portions

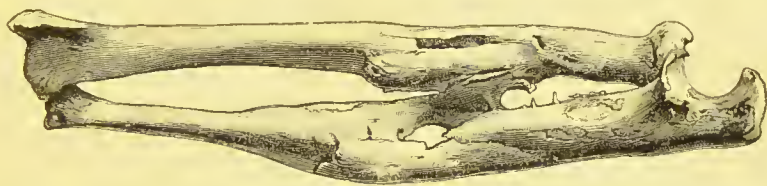


FIG. 118.—Excessive Callus Formation after Septic Compound Fracture of both Bones of Forearm—result of gun-shot wound. Fusion of Bones across Interosseous Space.

of bone may die, keeping up a persistent discharge, and when union takes place there is an excessive amount of callus, which may interfere with the function of the part. Operative interference is often called for to remove sequestra and permit of purification of the sinuses associated with them.

Excess of Callus.—In comminuted fractures, and in fractures in which there is much displacement, the amount of callus is in excess, but this is necessary to ensure stability. In fractures in the vicinity of large joints, such as the hip or elbow, the formation of callus is sometimes excessive, and the projecting masses of new bone restrict the movements of the joint. When exuberant callus forms between the bones in fractures of the forearm, pronation and supination may be interfered with (Fig. 118). Certain nerve-trunks, such as the musculospiral in the middle of the upper arm, or the ulnar at the elbow-joint, may become included in or pressed upon by callus.

Absorption of Callus.—It sometimes happens that when an

acute infective disease, especially one of the exanthemata, supervenes while a fracture is undergoing repair, the callus which has formed becomes softened and is absorbed. This may occur weeks or even months after the bone has united, with the result that the fragments again become movable, and it may be a considerable time before union finally takes place.

Tumours of Callus.—Tumours, such as chondromata and sarcomata and cysts, which are probably of the same nature as those met with in osteomyelitis fibrosa, are liable to occur in callus, or at the seat of old fractures, but the evidence so far is inconclusive as to the causative relationship of the injury to the new-growth. They are treated on the same lines as tumours occurring independently of fracture.

Badly United Fracture—Mal-Union.—Union with marked displacement of the fragments is most common in fractures that have not been properly treated—as, for example, those occurring in sailors at sea; and in cases in which the comminution was so great that accurate apposition was rendered impossible. It may also result from imperfect reduction, or because the apparatus employed permitted of secondary displacement. Restlessness on the part of the patient from intractability, delirium tremens, or mania, is the cause of mal-union in some cases.

Whether or not any attempt should be made to improve matters depends largely on the degree of deformity and the amount of interference with function.

When interference is called for, if the callus is not yet firmly consolidated, it may be possible, under an anæsthetic, to bend the bone into position or to rebreak it, either with the hands or by means of a strong mechanical contrivance known as an osteoclast. In the majority of cases, however, an open operation yields results which are more certain and satisfactory. When the deformity is comparatively slight, the bone is divided with an osteotome and straightened; when there is marked bending or angling, a wedge is taken from the convexity, as in the operation for bow-leg. To maintain the fragments in apposition it may be necessary to employ pegs, plates, bone ferrules, or other mechanical means. Splints and extension are then applied, and the condition is treated on the same lines as a compound fracture.

Delayed Union.—At the time when union should be firm and solid, it may be found that the fragments are only united by a soft cartilaginous callus, which for a prolonged period may undergo no further change, so that the limb remains incapable

of bearing weight or otherwise performing its functions. The normal period required for union may be extended from various



FIG. 119.—Un-united Fracture of Shaft of Humerus, of 15 years' duration.

causes. The most important of these is general debility, but the presence of rickets or tuberculosis, or an intercurrent acute

infectious disease, may delay the reparative process. The influence of syphilis, except in its gummatous forms, in interfering with union is doubtful. The influence of old age as a factor in delaying union has been over-estimated; in the great majority of cases, fractures in old people unite as rapidly and as firmly as those occurring at other periods of life.

Treatment.—The general condition of the patient should be improved as far as possible by dieting and tonics. One of the most reliable methods of hastening union in these cases is by inducing passive hyperæmia of the limb after the method advocated by Bier, and this plan should always be tried in the first instance. An elastic bandage is applied above the seat of fracture, sufficiently tightly to congest the limb beyond, and, to concentrate the congestion in the vicinity of the fracture, an ordinary bandage should be applied from the distal extremity to within a few inches of the break. The hyperæmia should be maintained for several hours (six to twelve) daily. An accurately fitting apparatus should be adjusted to enable the patient to get into the open air, and in fractures of the lower extremity we have found it an advantage to allow the patient to move about with crutches in the intervals. This method of treatment should be persevered with for three or four weeks, and the limb should be massaged daily while the bandage is off.

Among the other methods which have been recommended are the injection of oil of turpentine between the fragments (Mikulicz); the forcible rubbing of the ends together, under an anæsthetic if necessary; and the administration of thyroid extract. If these methods fail, the parts may be exposed by operation, and the ends of the bones rawed, and pegged, wired, or plated. As a rule, satisfactory union is ultimately obtained, although much patience is required.

Want of Union—"Un-united Fracture."—In a few cases union entirely fails to take place, and the condition is spoken of as un-united fracture. The most common local cause of non-union is the interposition of a portion of muscle, tendon, or other soft tissue between the ends of the bones. This is most liable to occur in oblique fractures with overlapping of the fragments, and it may be suspected if, with the X-rays, a clear space is seen between the fragments.

Any interference with the circulation of the limb, and any form of bacterial infection attended with suppuration in the region of the fracture, is liable to lead to non-union. Fractures inside the capsule of a joint, for example, the hip or shoulder, may also fail to unite, probably because the short fragment has

but a poor vascular supply, and because it is impossible to maintain accurate apposition of the fragments.

The fragments become atrophied, the ends rounded, and the medullary cavity obliterated, and the ends of the bone remain separate and freely movable. In course of time the ends of the bones may be covered by a layer of cartilage, and a firm capsule of fibrous tissue may form around them, and develop on its inner aspect a layer of endothelium which secretes a synovia-like fluid—a condition of affairs spoken of as a *false-joint* or *pseud-arthritis*. Sometimes dense fibrous tissue forms between the fragments, constituting *fibrous union*. In adults, non-union is most frequently met with in the humerus and in the femur, and in most cases union may be brought about by operative measures. In children, it is occasionally met with in the bones of the leg, and is seldom cured by operation. The lower fragments in these cases cease to grow and become rarefied, and the limb is so useless that amputation may be necessary.

If it has not already been tried, the usual treatment for delayed union should be instituted, and if this fails, recourse must be had to operation. The parts having been rendered bloodless, an incision is made to expose the fragments freely, and after removal of any intervening material and sawing of their surfaces, nails or wires are inserted to secure accurate apposition. The use of steel and aluminium plates fixed to the bone by screw-nails is sometimes a more efficient means of keeping the fragments in position. In certain cases dove-tailing the ends into one another, or enclosing the fragments in a ferrule of decalcified bone, may be employed. When the want of union is due to a defect in the bone, for example, after a comminuted fracture of the tibia, the gap may be filled by grafting into it a portion of the fibula from the opposite limb. Another method is to raise a broad flap of skin, periosteum, and bone from the opposite tibia, and, with its base still attached, to implant it in the gap. The limbs are held together with plaster of Paris until the graft has formed a vascular connection with the bone into which it is implanted, after which the base is divided and the limbs separated. This plan has been successful in those inveterate cases of non-union in children which previously necessitated amputation, and in cases of false-joint.

CHAPTER XXI

INJURIES OF JOINTS

SURGICAL ANATOMY—INJURIES : *Contusions; Wounds; Sprains; Dislocations*—**TRAUMATIC DISLOCATIONS:** *Causes; Varieties; Clinical features; Treatment*—Compound dislocations—Old-standing dislocations.

Surgical Anatomy.—The function of a joint is to permit of the movement of one bone upon another. The articular surfaces are covered with a thin layer of hyaline cartilage, and are retained in apposition by the tension of ligaments and of the muscles surrounding the joint. The capsular ligament is directly continuous with the periosteum, and is lined by synovial membrane, which at the line of attachment of the capsule is reflected on to the bone as far as the articular cartilage. The synovial membrane invests intra-articular ligaments, and is projected into the interior of the joint in the form of loose folds wherever the articulating surfaces are not in immediate contact. The surface of the membrane is covered with minute processes or villi, which in diseased conditions may become hypertrophied. The synovia owes its lubricating property to mucin, derived from the solution of the endothelial cells on the free surface of the membrane. The opposing surfaces of a joint being always in accurate contact, the so-called cavity is only a potential one. If fluid is poured out into the joint, the synovial membrane and the capsule are put upon the stretch, causing discomfort or actual pain, which is partly relieved by slightly flexing the joint. If the distension persists, the ligaments become elongated and the joint unstable.

The common origin of bone, cartilage, periosteum, and synovial membrane from one parent tissue of the embryo, accords with the readiness with which any one of these tissues may be converted into another under traumatic or pathological influences.

Joints derive an abundant blood-supply through the articular arteries. The lymphatics, which take origin in the synovial membrane, pass to efferent vessels which run in the intermuscular and other connective-tissue planes of the limb. The nerve supply is derived chiefly from the nerves distributed to the muscles acting on the joint and to the skin over it.

Sources of Joint Strength.—The capacity of a joint to resist dislocation depends upon (1) the shape of its osseous elements; (2) the strength and arrangement of its ligaments; (3) the support it receives from muscles or tendons placed in relation to it; and (4) the relative stability of adjacent structures. While all these factors contribute to the strength of a given joint, one or other of them usually predominates, so that certain joints

are osseously strong, others are ligamentously strong, while a few depend chiefly upon adjacent muscles for their stability.

The hip and elbow are the best examples of joints deriving their strength mainly from the architectural arrangement of the constituent bones. These joints are dislocated only by extreme degrees of violence, and not infrequently—especially in the elbow—portions of the bones are fractured before the articular surfaces are separated.

The knee, the wrist, the carpal, the tarsal, and the clavicular joints depend for their stability almost entirely on the strength of their ligaments. These joints are rarely dislocated, but as the main incidence of the violence falls on the ligaments they are frequently sprained.

The shoulder is the typical example of a joint depending for its security chiefly upon the muscles and tendons passing over it, and hence the frequency with which it is dislocated when the muscles are taken unawares. At the same time the great mobility of the scapula and clavicle materially increases the stability of the shoulder-joint. The tendons passing in relation to the knee, ankle, and wrist add to the stability of these joints.

The proximity of an easily fractured bone also contributes to prevent dislocation of certain joints—for example, fracture of the clavicle prevents an impinging force expending itself on the shoulder-joint; and the frequency of Colles' fracture of the radius, and of Pott's fracture of the fibula, doubtless accounts to some extent for the rarity of dislocation of the wrist and ankle joints respectively. The immunity from dislocation which the joints of young subjects enjoy is partly due to the ease with which the adjacent epiphyses are separated.

The mechanical axiom that "what is gained in movement is lost in stability" is true of joints, those which have the widest range of movement being the most frequently dislocated.

The injuries to which a joint is liable are Contusions, Wounds, Sprains, and Dislocations.

Contusions of Joints.—Contusion is the mildest form of injury to a joint. Whether the violence is transmitted from a distance, as in contusion of the hip from a fall on the feet, or acts more directly, as in a fall on the great trochanter, the bones are violently driven against one another, and the force expends itself on their articular surfaces. The articular cartilages and the underlying spongy bone, as well as the synovial membrane, are bruised, and there is an effusion of blood and serous fluid into the joint and surrounding tissues.

The most prominent *clinical features* are swelling and discoloration. The swelling, especially in superficially placed joints, is an early and marked symptom, and is mainly due to the effusion of blood into the joint (*hæmarthrosis*). In deeply placed joints, discoloration may not appear on the surface for some days, especially if the violence has been indirect. The joint is kept in the flexed position, and is painful only when moved. Considerable effusion of blood into a joint may follow the most trivial injury in hæmophilic subjects.

A slight degree of serous effusion into the joint (*hydrarthrosis*) often persists for some time, and tuberculous affections of joints not infrequently date from a contusion.

Treatment.—When seen immediately after the accident, effusion may be prevented by applying firm pressure with an elastic bandage over a thick layer of cotton wool. After a few hours, massage and movement of the joint are commenced, and systematically employed. When effusion has already taken place and there is so much fluid in the joint as to interfere with movement, absorption may be promoted by withdrawing some of the fluid by means of an exploring needle, after which massage and movement are begun. Prolonged rest is to be avoided, as it results in stiffness and impaired or delayed usefulness.

Wounds of Joints.—The importance of accidental wounds of joints—such, for example, as result from a stab with a pen-knife or the point of a railing—lies in the fact that they are liable to be followed by septic infection of the synovial cavity. The infection may involve only the synovial membrane (*septic synovitis*), or may spread to all the elements of the joint (*septic arthritis*). These conditions are described with diseases of joints.

Penetration of the joint may sometimes be recognised by the escape of synovia from the wound, or the synovial membrane or articular cartilage may be exposed. When doubt exists, the wound should be enlarged. The use of the probe is to be avoided, on account of the risk of carrying septic material from the track of the wound into the cavity of the joint.

Penetrating wounds of joints are treated on the same lines as those associated with compound fractures. After the wound has been disinfected, a Bier's bandage is applied and drainage provided for. As soon as the wound is healed, massage and movement must be employed to prevent the formation of adhesions.

Gun-shot injuries of joints have already been described.

Sprains.—A sprain results from a stretching or twisting form of violence which causes the joint to move beyond its physiological limits, or in some direction for which it is not structurally adapted. The main incidence of the force therefore falls upon the ligaments, which are suddenly stretched or torn. The synovial membrane also is torn, and the joint becomes filled with blood and serum.

Muscles and tendons passing over the joint may be stretched

or torn, and their sheaths filled with serous effusion. It is not uncommon for superficial portions of bone to be torn off at the site of attachment of strong ligamentous bands or tendons, constituting a "sprain fracture"; or for intra-articular cartilages to be displaced, as in the knee.

Clinical Features.—The injury is accompanied by intense sickening pain, and this may persist for a considerable time. At first it is aggravated by moving the joint, but if the movement is continued it tends to pass off. The particular ligaments involved may be recognised by the tenderness which is elicited on making pressure over them, or by putting them on the stretch. In this way a sprain may often be diagnosed from a fracture.

The effusion of blood and serum into the joint and into the tissues around gives rise to swelling and discoloration, and the fluid effused into tendon sheaths often produces a peculiar creaking sensation, which may be mistaken for the crepitus of fracture. In sprains, the bony points about the joint retain their normal relations to one another, and this usually enables these injuries to be diagnosed from dislocations, and, as a rule, from fractures. When the swelling is great, it is often necessary to have recourse to the Röntgen rays to make certain that there is no fracture or dislocation.

Prognosis.—Stiffness, lasting for a longer or shorter time, follows most sprains, but may be largely prevented by proper treatment. In old and rheumatic persons, changes of the nature of arthritis deformans are liable to supervene, interfering greatly with movement. While suppuration is rare, tuberculous disease not infrequently dates its onset from a sprain.

Treatment.—Sprains are best treated by early massage and movement. In the ankle, for example, massage should be commenced at once, the part being gently stroked upwards. If the massage is light enough there is no pain, it is actually soothing. The rubbing is continued for from fifteen to twenty minutes, and the patient is encouraged to move the toes and ankle. A moderately firm elastic bandage is then applied, care being taken not to constrict the limb and so interfere with the circulation. The massage is repeated once or twice a day, the sittings lasting for about fifteen minutes. The patient should be encouraged to move the joint from the first, beginning with the movements that put least strain upon the damaged ligaments, and gradually increasing the range. In the course of a few days he is encouraged to walk or cycle, or otherwise to use the joint without subjecting it to strain. Alternate hot

and cold douching, or hot-air baths, followed by massage, are also useful. Complete rest and prolonged immobilisation are to be condemned.

TRAUMATIC DISLOCATIONS

A dislocation or luxation is a persistent displacement of the opposing ends of the bones forming a joint. We are here concerned only with such dislocations as immediately follow upon injury. Those that are congenital or that result from disease will be studied later.

Causes.—The majority of dislocations are the result of *indirect* violence, the more movable bone acting as a lever, on a fulcrum furnished by the natural check to movement in the form of ligament, bone, or muscle. It is in this way that most dislocations of the shoulder, hip, and elbow are produced.

At the moment the violence is applied, the muscles are relaxed or otherwise taken at a disadvantage, so that the joint is for the time being deprived of their support. The joint is moved beyond its physiological range, and the end of one of the bones being brought to bear upon the capsule, tears it, and passes through the rent thus made. The muscles then contract reflexly, and pull the head of the bone into an unnatural position outside the capsule. The position assumed will depend upon such factors as the direction of the force, the shape of the joint, the position of the limb at the time of the accident, and the relative strength of the different groups of muscles acting upon the bone which is displaced.

Violence applied *directly* to the joint is a much less frequent cause of dislocation. In this way, however, the knee-joint may be dislocated, one bone being driven past the other—for example by a kick from a horse; or the acromio-clavicular joint by a blow on the shoulder.

Muscular contraction is not often the sole cause of dislocation, although, as has been mentioned, it plays an important rôle in the production of the majority of these injuries. The shoulder, lower jaw, and patella are, however, not infrequently displaced by muscular action alone. Acrobats sometimes acquire the power of dislocating certain joints by voluntary contraction of their muscles.

Age and Sex.—Dislocations occur most frequently in adult males, doubtless on account of the nature of their occupations and recreations. In children the epiphyses are separated, and

in old people the bones are broken by such forms of violence as cause dislocation in the middle-aged.

Muscular debility and undue laxness of ligaments resulting from disease or previous dislocation are also predisposing factors.

Clinical Varieties.—The separation between the bones may be *complete* or *partial*. When partial, portions of the articular surfaces remain in apposition, and the injury is known as a *sub-luxation*. Like fractures, dislocations may be *simple* or *compound*, the latter being specially dangerous on account of the risk of septic infection. When seen within a few days of its occurrence, a dislocation is looked upon as *recent*; but when several weeks or months have elapsed, it is spoken of as an *old-standing* dislocation. The latter will be described on p. 470.

Dislocations, like fractures, may be *complicated* by injuries to large blood-vessels or nerve-trunks, by injuries to internal organs, or by a wound of the soft tissues which does not communicate with the joint. Further, a fracture may coexist with a dislocation.

Clinical Features.—The most characteristic signs of dislocation are *preternatural rigidity*, or want of movement where movement should naturally take place; *mobility in abnormal directions*; and *deformity*, the part being “out of drawing” as compared with the uninjured side (Fig. 129). The bony landmarks lose their normal relationship to one another; and the deformity is characteristic, and is common to all examples of the same dislocation.

Although any of the subsidiary signs may occur in lesions other than dislocations, due weight must be given to them in making a diagnosis. *Loss of function* is complete as a rule. *Pain* is much more intense than in fracture, usually because the displaced bone presses upon nerve-trunks, and from the same cause there is often numbness and partial paralysis of the limb beyond. *Swelling* of the soft parts due to effused blood is usually less marked in dislocation than in fracture, but is often sufficiently great to interfere with diagnostic manipulations. The displaced bone, and sometimes the empty socket, may be palpable. *Discoloration* is usually later of appearing than in fractures. *Alteration in the length* of the injured limb—usually in the direction of shortening—is a very constant feature; while girth measurements commonly show an increase. A peculiar soft *grating* or *creaking sensation* is often felt on attempting to move the joint; this is due to car-

tilaginous or ligamentous structures rubbing on one another, and must not be mistaken for the crepitus of fracture. In the great majority of cases, although not in all, after reduction has been effected, the bones retain their proper relations without external support, a point in which a dislocation differs from a fracture. A careful investigation of the kind of force which produced the injury, particularly as regards its intensity and direction of action, may aid in the diagnosis. The diagnosis can always be verified by the use of the Röntgen rays, and this should be had recourse to whenever possible.

Prognosis.—After having once been dislocated, a joint is seldom as strong as it was formerly, although for all practical purposes the limb may be as useful as ever. Some degree of stiffness, of limited movement, or of muscular weakness, and occasional arthritic pains and a liability to re-dislocation, are the commonest sequelæ. Prolonged immobilisation is liable to lead to stiffness by permitting of the formation of adhesions, or of fibrous thickenings of tendons or ligaments; while too early movement tends to produce a laxity of the ligaments which favours re-displacement from slight causes.

Treatment.—Reduction should be attempted at the earliest possible moment. Every hour of delay increases the difficulty. The guiding principle is to cause the displaced bone to re-enter its socket by the same route as that by which it left it—that is, through the existing rent in the capsule. This is done by carrying out certain manipulations which depend upon the anatomical arrangement of the parts, and which vary, not only with different joints, but also with different varieties of dislocation of the same joint. In general terms it may be said that the main impediments to reduction are: the contraction of the muscles acting upon the displaced bone; the entanglement of the bone among tendons or ligamentous bands which fix it in its abnormal position; and the rent in the capsule being small or valvular, so that it forms an obstacle to the bone re-entering the socket.

Muscular contraction is best overcome by the administration of a general anæsthetic, and in all but the simplest cases this should be given to ensure accurate and painless reduction. Failing this, however, the muscles may be wearied out by the surgeon making steady and prolonged traction on the limb, while an assistant makes counter-extension on the proximal segment of the joint. Advantage may also be taken of such muscular relaxation as occurs when the patient becomes faint, or when his attention is diverted from the injured part, to

carry out the manipulations necessary to restore the bone to its normal position.

The appropriate manœuvres for disengaging the head of the bone from tendons, ligaments, or bony processes with which it may be entangled, will be suggested by a consideration of the anatomy of the particular joint involved, and will be described with individual dislocations.

It cannot be urged too strongly that any mechanical apparatus in the form of pulleys, levers, or fulcra is only to be used in exceptional cases and with the greatest care and caution. In reducing a dislocation, no amount of physical force will compensate for a want of anatomical knowledge. All tugging, twisting, or wrenching movements are to be avoided, as they are liable to cause damage to blood-vessels, nerves, or other soft parts, or even—and especially in old people—to fracture one of the bones concerned.

Great benefit is gained by the systematic use of *massage* and movement. Before any restraining apparatus is applied the whole region around the joint should be gently stroked in a centrifugal direction for fifteen or twenty minutes; and this is to be repeated daily, each sitting lasting for about twenty minutes. From the first day onward movement of the joint is carried out in every direction, except that which tends to bring the head of the bone against the injured part of the capsule; and the patient is encouraged to use the joint as early as possible. The appropriate apparatus and the period during which it should be worn will be considered with the individual dislocations.

Operation in Simple Dislocations.—In a limited number of cases, even with the aid of an anæsthetic, reduction by manipulation is found to be impossible. Resort must then be had to operation, which under aseptic conditions is a comparatively safe and satisfactory proceeding, although often difficult. It may happen that the undoing of the displacement is only possible after the removal of a portion of one or other of the bones.

Compound Dislocations.—Compound dislocations are usually the result of extreme violence produced by machinery or railway accidents, or by a fall from a height. In the majority of cases they are complicated by fracture of one or more of the constituent bones of the joint, as well as by laceration of muscles, tendons, and blood-vessels. In the region of the ankle, wrist, and joints of the thumb, however, compound dislocation is sometimes met with uncomplicated by other

lesions. The great risk is septic infection, which may result in serious impairment of the usefulness of the joint or even in its complete destruction, results towards which the concomitant injuries materially contribute. In many instances where septic infection has occurred, ankylosis is the best result that can be hoped for.

Treatment.—As a rule, the first question that arises is whether amputation is necessary or not, and the considerations that determine this point are the same as in the case of compound fractures (p. 451).

When an attempt is to be made to save the limb, the dislocation is reduced after the parts have been thoroughly purified, and to admit of this it is sometimes necessary to excise portions of bone. Drainage-tubes are inserted, the rest of the wound closed, and a retentive apparatus applied, provision being made for dressing the wound.

Dislocation complicated by Fracture.—In certain dislocations the separation of small portions of bones or of epiphyses is of almost constant occurrence—for example, fracture of the tip of the coronoid process in dislocation of the elbow backwards, and chipping off of a portion of the edge of the acetabulum in dislocation of the hip. These neither add to the difficulties of diagnosis nor necessitate any modification of the treatment, and they need not be further referred to.

The commonest example of a fracture complicating a dislocation is fracture of the neck of the humerus coexisting with dislocation of the shoulder. Here the difficulty of diagnosis is greatly increased, and the treatment of both injuries requires to be modified. The dislocation must be reduced—by operation if necessary—before the fracture is treated, and in many cases it is advisable to secure the fragments of the broken bone by wires, pegs, or plates, to admit of movement being commenced early, and so to prevent stiffness of the joint.

Old-standing Dislocations.—When, from oversight or from unsuccessful treatment, a dislocation is left for some time unreduced, changes take place in and around the joint which render replacement by manipulation extremely difficult or impossible. The rent in the capsule closes upon the neck of the bone, and fibrous adhesions form between muscles, tendons, and other structures that have been torn. The articular cartilage of the head, being no longer in contact with an opposing cartilage, tends to be converted into fibrous tissue, and may become adherent to other fibrous structures in its vicinity. By

pressing on adjacent structures it may form for itself a new socket of dense fibrous tissue which in time becomes lined with a secreting membrane. When the displaced head lies against a bone, the continuous pressure produces a new osseous socket, from the margins of which osteophytic outgrowths may spring, and as the surrounding fibrous tissue becomes condensed and forms a strong capsule, a new joint results. Meanwhile the cartilage of the original socket is converted into fibrous tissue, which may come to fill up the cavity. Changes resembling those of arthritis deformans may occur. The large blood-vessels and nerves in the vicinity may be pressed upon or stretched by the displaced bone, or may be implicated in fibrous adhesions. In course of time they become lengthened or shortened in accordance with the altered attitude of the limb.

In many cases the new joint is remarkably mobile and useful; but in others, pain, limited movement, and atrophy of muscles render it comparatively useless and call for surgical intervention.

Treatment.—It is always a difficult problem to determine the date after which it is inadvisable to attempt reduction by manipulation, and no rules can be laid down which will cover all cases. Rather must each case be decided on its own merits, due consideration being had to the risks that attend this line of treatment. The chief of these are: rupture of large blood-vessels or nerves that have formed adhesions with the displaced bone, or have become shortened in adaptation to the altered shape or length of the limb; tearing of muscles or tendons, or even of skin; fracture of the bone, especially in old people; and separation of epiphyses in the young.

Before carrying out the manipulations appropriate to the particular dislocation, all adhesions must first be broken down; and during the proceedings no undue force is to be employed. It is sometimes found that the displacement is prone to recur, even after reduction has been successfully accomplished.

When reduction by manipulation is inadvisable or has been unsuccessful, the question of operation arises. In this connection it is to be borne in mind that even with an open wound the replacement of the bone is often by no means easy, and it may be necessary to excise the head of the bone. Before deciding to operate, however, the surgeon must consider the amount of disability which the condition entails, and to what extent this is likely to be improved by the operation.

Habitual or recurrent dislocation is almost exclusively met

with in the shoulder, and will be described with the injuries of that joint.

Pathological Dislocations.—Joints may become dislocated in the course of certain diseases. These pathological dislocations fall into three groups: (1) those due to gradual stretching of the capsular and other ligaments weakened by inflammatory and suppurative processes, such as sometimes follow on typhoid, scarlet fever, or diphtheria, and in pyæmia; (2) those due to destructive changes in the ligaments and bones—typically seen in tuberculous arthritis, in arthritis deformans, and in Charcot's disease; (3) those associated with Deformities.

These will be considered with the diseased conditions which give rise to them.

Congenital Dislocations.—Congenital dislocations are believed to be the result of abnormal or arrested development *in utero*, and are to be distinguished from dislocations occurring during birth, which are essentially traumatic in origin. They will be described along with Deformities.

CHAPTER XXII

INJURIES IN THE REGION OF THE SHOULDER AND UPPER ARM

Surgical Anatomy—FRACTURES OF CLAVICLE: *Varieties*—DISLOCATIONS OF CLAVICLE: *Varieties*—DISLOCATIONS OF SHOULDER: *Varieties*—Sprains and contusions of shoulder—FRACTURES OF SCAPULA: Sites—FRACTURES OF UPPER END OF HUMERUS: *Surgical neck; Separation of epiphysis; Fracture of head, anatomical neck, or tuberosities*—FRACTURES OF SHAFT OF HUMERUS.

THE injuries met with in the region of the shoulder include fractures and dislocations of the clavicle, fractures of the scapula, dislocations and sprains of the shoulder-joint, and fractures of the upper end of the humerus.

Surgical Anatomy.—For the examination of an injury in the region of the shoulder the patient should be seated on a low stool or chair. After inspecting the parts from the front, the surgeon stands behind the patient and systematically examines by palpation the shoulder girdle and upper end of the humerus. The uninjured side should be examined along with the other for purposes of comparison.

Immediately external to the supra-sternal notch, the sternoclavicular articulation may be felt, the large end of the clavicle projecting beyond the margins of the small and shallow articular surface on the sternum. Any dislocation of this joint is at once recognised. The clavicle being subcutaneous throughout its whole length, any irregularity in its outline can be easily detected. A small tubercle (deltoid tubercle) which frequently exists near the acromial end is liable to suggest the presence of a fracture. The outer end forms with the acromion the acromioclavicular joint, which, however, is not always readily recognised. The fingers are now carried over the acromion, which often exhibits in the situation of its epiphysal cartilage a prominent ridge, which must not be mistaken for a fracture. The tip of the acromion is usually employed as a fixed point in measuring the length of the arm.

The outline of the spine of the scapula can be traced back to the vertebral border; and the body of the bone may be manipulated, and its movements tested by moving the arm.

The coracoid process can be recognised in the upper and outer angle of the triangular depression bounded by the pectoralis major, the deltoid, and the clavicle.

The head and surgical neck of the humerus may now be felt from the axilla, if the axillary fascia is relaxed by bringing the arm to the side. The great tuberosity can be indistinctly felt on the outer aspect of the shoulder through the fibres of the deltoid. It lies vertically above the external condyle, and may be recognised to rotate with the shaft. The bicipital groove looks forward, and lies in a line drawn vertically through the biceps muscle.

The subclavian artery, with its vein to the inner side and the cords of the brachial plexus to the outer side, passes under the middle of the clavicle, and may be compressed against the first rib immediately above this bone.

FRACTURE OF THE CLAVICLE

Fracture of the clavicle is one of the commonest injuries met with in practice. As about one-third of the cases occur in children, the fracture is often of the greenstick variety. The fractures are seldom compound or complicated, unless

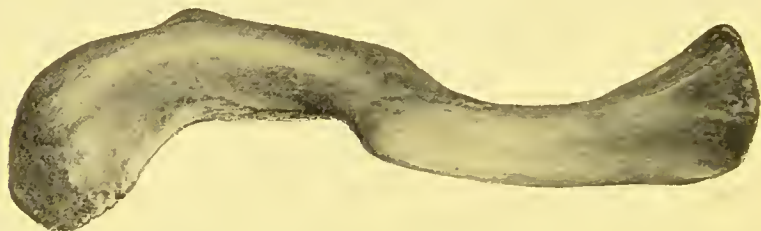


FIG. 120.—Oblique Fracture of Right Clavicle in Middle Third, united.

as a result of gun-shot injuries; but occasionally one of the fragments pierces the skin, or comes to press upon the subclavian vessels or the cords of the brachial plexus, arresting the pulsation in the vessels of the limb, and causing severe pain in the arm.

The most common site of fracture is in the *middle third* (Fig. 120), and this usually results from indirect violence, such as a fall on the outstretched hand, the elbow, or the outer aspect of the shoulder, the force being transmitted through the glenoid cavity to the scapula, and thence by the coraco-clavicular ligaments to the clavicle. The violence is therefore of a twisting character, and the bone gives way near the junction of the outer and middle thirds, just where the two natural curves of the bone meet, and where the supporting muscular and ligamentous attachments are weakest.

The fracture so produced is usually oblique from above, downwards and inwards. The sternal fragment may be slightly

drawn upwards by the clavicular fibres of the sterno-mastoid, while the outer fragment falls by the weight of the arm, and the fragments usually overlap to the extent of about half an inch. The shoulder, having lost the buttressing support of the clavicle, falls in towards the chest wall, narrowing the axillary space, while the weight of the arm pulls it downward, and the muscles inserted in the region of the bicipital groove pull it forward.

Fracture of the middle third may result also from a direct stroke, such as the recoil of a gun, or from violent muscular contraction, the fracture as a rule being transverse, and the displacement less marked than in fracture by indirect violence.

Clinical Features.—The attitude of the patient is characteristic: the elbow is flexed and is supported by the opposite hand, while the head is inclined towards the affected shoulder to relax the muscles of the neck. Crepitus is elicited on bracing back the shoulders, or on attempting to raise the arm beyond the horizontal, and these movements cause pain. Tenderness is elicited on making pressure over the seat of fracture, and also on distal pressure. The sternal fragment almost invariably overrides the acromial, and can usually be palpated through the skin; on measurement, the clavicle is found to be shortened. When the fracture is incomplete (greenstick) or transverse, the symptoms are less marked.

Simultaneous fracture of both clavicles usually results from a severe transverse crush of the upper part of the thorax or from a fall on the outstretched hands. The middle third of the bone is implicated, and there is marked displacement and overriding. The patient is rendered helpless, and from the extrinsic muscles of respiration being thrown out of action, and the weight of the powerless limbs pressing on the chest, he has considerable difficulty in breathing, and this is often increased by the fracture being complicated by injuries of the lung or pleura.

Fracture of the *outer third* of the clavicle is much less common, and usually results from direct violence, the bone being driven down against the coracoid process, and broken as one breaks a stick over the knee. The fracture may take place through the attachment of the conoid and trapezoid ligaments, in which case the only symptoms are pain and tenderness at the seat of fracture, with impaired movement of the limb. Displacement and crepitus are prevented by the splinting action of the ligaments.

When the break is external to the attachment of the trapezoid ligament, the fracture is usually transverse, and is almost always due to a fall on the back of the shoulder—the angle between the spine and the acromion process striking the ground. The outer fragment rotates forward (Fig. 121), sometimes even to a right angle, causing the tip of the shoulder to pass forwards, and so to lie slightly nearer the middle line. The integrity of the coraco-clavicular ligaments prevents any marked drooping of the shoulder. It is noteworthy that the displacement is not always evident at first.

Fractures of the *inner third* are rare, are usually oblique, and result either from an indirect force acting in the line



FIG. 121.—Fracture of Outer End of Clavicle. Shows forward rotation of outer fragment, and line of fracture united by osseous callus.

of the clavicle, or, less frequently, from direct violence or muscular action. As a rule, the deformity is insignificant, except when the costo-clavicular ligament is torn, in which case the inner end of the outer fragment is tilted up by the weight of the arm. The shoulder passes downwards, forwards, and inwards. When close to the sternal end, this fracture may simulate a dislocation of the sterno-clavicular joint or a *separation of the clavicular epiphysis*. This last is a very rare accident, which may occur between the seventeenth and the twenty-fifth years, and is usually the result of violent muscular action. It differs from the other injuries in this region in being more easily reduced and retained in position, the epiphysis lying entirely within the limits of the capsular ligament of the sterno-clavicular joint.

The *prognosis* as to union in all these injuries is good. Firm bony union usually occurs within twenty-one days.

Non-union, false-joint, or fibrous union is but rarely met with. At the same time it is to be borne in mind that, in spite of all precautions, some deformity and shortening may result, without, however, interfering with the usefulness of the limb.

Treatment.—The displacement in complete fractures of the clavicle is readily reduced by supporting the elbow, bracing back the shoulders, and levering out the tip of the affected shoulder. In a few cases the interposition of some fibres of the subclavius muscle between the fragments has prevented perfect reduction.

In the greenstick variety the bone may be bent back into its normal position, but no great force should be employed, as, in spite of imperfect reduction, the clavicle usually straightens as it grows, and although some deformity may persist, the function of the limb is not interfered with.

Treatment in the Recumbent Position.—There is little doubt that the most perfect æsthetic results are obtained by treating the patient in the recumbent position. In the case of girls, therefore, in whom it is desired that the shoulders should be perfectly symmetrical, the best method

of treatment is to place the patient on a firm mattress, with a narrow, firm cushion between the shoulder-blades, so that the weight of the shoulder may carry the acromial fragment outwards and backwards. A pad is inserted in the axilla, the elbow raised, and the arm placed by the side on a pillow and steadied with sand-bags. Massage is applied daily. As this position must be maintained uninterruptedly for two or three weeks, it proves too irksome for most patients. When both clavicles are fractured, however, it is, short of operation, the only available method of treatment, and the patient must be carefully nursed to prevent him moving the arms.



FIG. 122.—Adhesive plaster applied for Fracture of Clavicle.

In ordinary cases the arm should be placed in that position which gives the best alignment of the fragments and least deformity. A thin layer of wool is placed in the axilla to separate the skin surfaces. A sling, supporting the *elbow*, is now applied, maintaining the arm in position, and a body bandage fixes the arm to the side. Massage and movement should be commenced at once.

A simple method, which yields satisfactory results, is that suggested by Wharton Hood. The fracture having been reduced, three strips of adhesive plaster, each an inch and a half wide, are applied from a point immediately above the

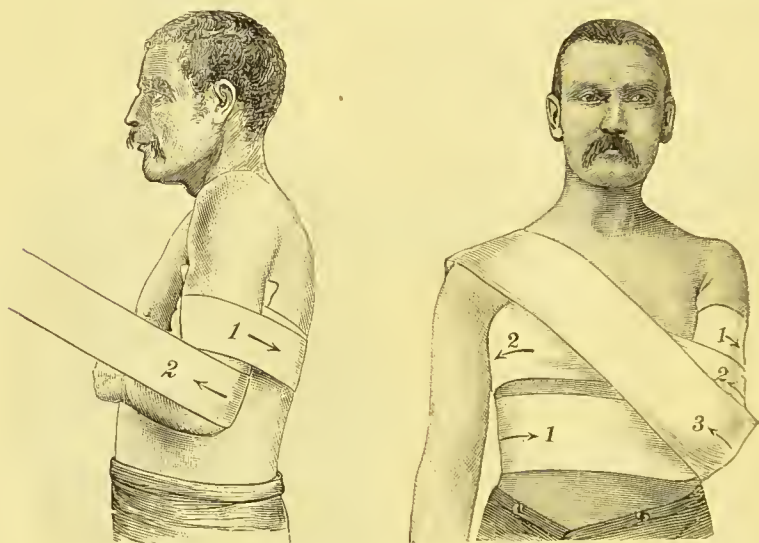


FIG. 123.—Duncan's modification of Sayre's Method of treating Fracture of Clavicle. The *circular* body bandage has still to be applied.

nipple to a point two inches below the angle of the scapula (Fig. 122). The middle strap covers the seat of fracture, and should be applied first; the lateral ones, slightly overlapping it, should extend about half an inch on either side. The elbow is supported in a sling. This plan has the advantage that it permits of movement of the shoulder being carried out from the first, but the plaster rather interferes with the massage.

Sayre's method, which is specially adapted to fractures of the middle third, although applicable to all, consists in applying broad strips of adhesive plaster in such a way as to correct the threefold deformity. While it is excellent in principle, it is often found troublesome in practice, as the plaster is uncom-

fortable, and if it becomes slack and fails to correct the deformity, must be completely removed and reapplied. These difficulties may to some extent be overcome by adopting *Duncan's modification*, which consists in employing a broad domette bandage in place of the adhesive plaster. A layer of wool is placed in the axilla to keep the skin surfaces apart. A wide loop is made on the end of the bandage, and passed round the middle of the upper arm (Fig. 123), care being taken that the limb is not constricted. The arm is pulled backward by carrying the bandage across the back, under the opposite axilla, and round the thorax as far as the elbow. It is next looped

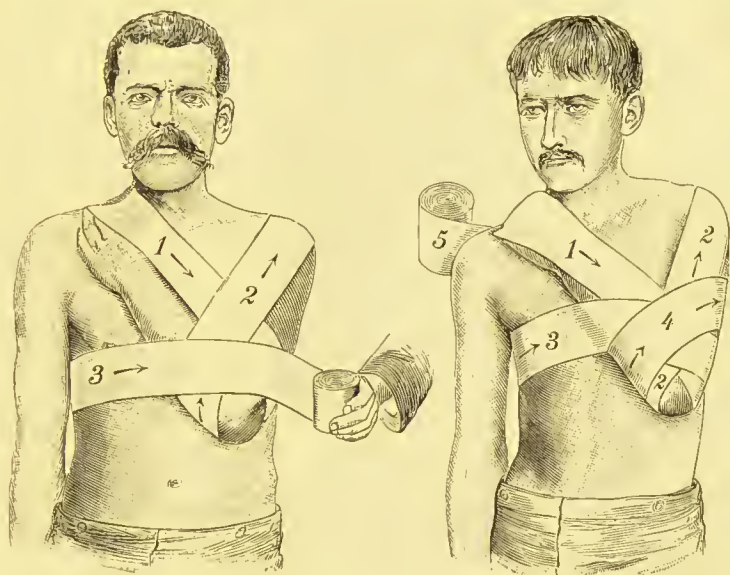


FIG. 124.—Chiene's Method of treating Fracture of Clavicle.

round the back of the elbow, close above the condyles, and by being carried across the front of the chest to the opposite shoulder pulls the elbow forward and inward, and so levers the shoulder backward and outward on the fulcrum formed by the loop round the upper arm. The next turn corrects the downward displacement by passing across the back, under the tip of the elbow—a slit being made in the bandage opposite the olecranon process—and along the forearm to the opposite shoulder. A circular body bandage is applied over all these turns, and safety-pins inserted at the crossings.

“Lay the tail of the bandage on the hand (Fig. 124); carry it down the back of the forearm, round the elbow, up the

upper arm to the tip of the acromion (2), across the back to the opposite axilla, across the forearm (3), round the elbow again, up the upper arm, then round below the deltoid (4), and across the back to the opposite shoulder (5), repeating these turns as often as is necessary. Last of all, fix the arm to the side by circular turns" (John Chiene).

The Handkerchief Method.—In cases of emergency, one of the best methods applicable to all fractures of the clavicle is to brace back the shoulders by means of two padded handkerchiefs, folded *en cravate*, placed well over the tips of the shoulders and tied, or interlaced, between the scapulæ. The forearm is then supported by a third handkerchief applied as a sling, the base of which is placed under the elbow, the ends passing over the sound shoulder.

Operative treatment may be called for in compound or comminuted fractures when the fragments have injured, or are likely to injure, the subclavian vessels or the cords of the brachial plexus, or when it is otherwise impossible to reduce the fracture or to retain the fragments in apposition. It is also indicated in some cases of fracture of both clavicles. Silver wire or silk-worm gut is the most suitable material for suture. Massage and movement are employed, as in simple fractures.

These various methods of treatment are not equally applicable to all cases. In our experience, in the circumstances indicated, the following methods have proved the most satisfactory:—(1) As a temporary means of retention in emergency cases, for example, accidents occurring on the football field, the handkerchief method. (2) In uncomplicated fractures of average severity in any part of the bone, the method of sling and body bandage. (3) In cases where, for æsthetic reasons, the chief consideration is the avoidance of deformity and the maintenance of the symmetry of the shoulders, as in girls, the treatment by recumbency. (4) When retentive apparatus fails, or when the fragments are exerting injurious pressure, operative treatment.

DISLOCATIONS OF THE CLAVICLE

Dislocation of the **acromial end**—sometimes, and perhaps more correctly, spoken of as dislocation of the scapula—is more frequent than that at the sternal end, and it usually results from a blow from behind, or from a fall on the tip of the shoulder, driving down the scapula, so that the clavicle projects *upwards* and overrides the acromion process.

Downward displacement of the outer end of the clavicle is much rarer, and may follow a fall on the elbow or a blow over the clavicle. The end of the bone lies under the acromion process, in contact with the capsule of the shoulder-joint, and the acromion stands out prominently.

The *clinical features* are so well marked that the diagnosis is unmistakable. The head inclines towards the affected side, and the tip of the shoulder tends to pass slightly downward, forward, and inward. The displaced end of the bone can be seen and felt as a prominence under the skin (Fig. 125), or the



FIG. 125.—Dislocation of Acromial End of Left Clavicle upwards.

empty socket can be palpated, while the muscles attached to the displaced clavicle stand out in relief. The movements at the shoulder are restricted, particularly in the direction of abduction above the level of the shoulder. These injuries are sometimes associated with fracture of the ribs, a complication which adds materially to the difficulties of treatment.

Treatment.—Reduction is easily effected by bracing back the shoulders and replacing the bone in its socket by manipulation; but retention is invariably difficult, and in many cases impossible; even when the displacement is permanent, however, the usefulness of the arm is not necessarily impaired.

Treatment is similar to that for fracture of the clavicle

by sling and body bandage. Another plan is to place an elastic pad, such as a Turkey sponge, over the outer end of the clavicle, and fix it in this position by a few turns of elastic bandage carried over the shoulder and under the elbow. The forearm is placed in a sling with the elbow well supported, and the arm is bound to the side by a circular bandage (Fig. 126). When the bone cannot be kept in position and the usefulness of the limb is impaired, the joint surfaces may be rawed and the bones wired, with a view to obtaining ankylosis.

The sternal end may be dislocated forwards, backwards, or upwards.

Forward dislocation is the most common; the end of the clavicle lies on the front of the sternum, somewhat below the level of the sterno-clavicular joint, and its articular surface can be distinctly palpated (Fig. 127). The inter-articular cartilage sometimes remains attached to one bone, sometimes to the other; the rhomboid ligament is usually intact.

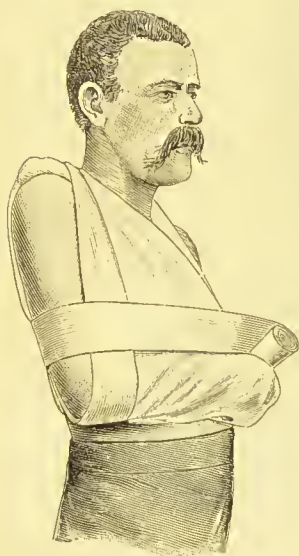


FIG. 126.—Treatment of Upward Dislocation of Acromial End of Clavicle.

In the *backward* dislocation the end of the clavicle lies behind the manubrium sterni and the muscles attached to it; there is a marked hollow in the position of the joint, and the facet on the sternum can be felt. In a comparatively small number of cases the bone exerts pressure upon the trachea and œsophagus, producing difficulty in breathing and swallowing. It has also been known to press upon the subclavian artery and on other important structures at the root of the neck.

In rare cases the rhomboid ligament is torn, and the end of the clavicle passes *upwards*, and rests in the episternal notch behind the sterno-mastoid muscle.

The bone may be retained in position by keeping the shoulders braced back by a figure-of-eight bandage, or by padded handkerchiefs, and making pressure over the displaced end of the bone with a sponge-pad. The forearm is supported by a sling, and the arm fixed to the side. Massage is employed from the first, and the patient is allowed to move the arm by the end of a week. Imperfect reduction interferes so little

with the functions of the limb, that operative measures are seldom required except for æsthetic reasons.

Dislocation of **both ends** of the clavicle has occasionally occurred from a severe crush. The ultimate result has been satisfactory, as one or other end has always healed in normal position, and the function of the arm has thus been maintained.

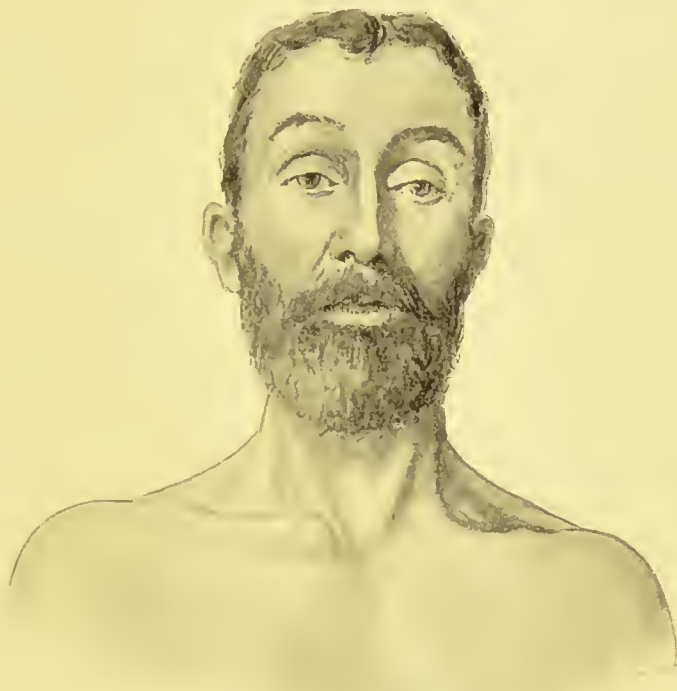


FIG. 127.—Forward Dislocation of Sternal End of Right Clavicle.

DISLOCATIONS OF THE SHOULDER

The shoulder is more frequently dislocated than all the other joints in the body taken together. This is explained by its exposed position, the wide range of movement of which it is capable, the length of the lever afforded by the humerus, and the anatomical construction of the joint—the large, round humeral head imperfectly fitting the small and shallow glenoid cavity, and the ligaments being comparatively lax and thin. The capsule of the joint is materially strengthened in its upper and back parts by the tendons of the supra- and infra-spinatus

and teres minor muscles; while it is weakest below and in front, between the subscapularis and teres major tendons. It is here that it most frequently gives way and allows of escape of the head of the bone.

The violence is usually transmitted from the hand or elbow, less frequently from the outer aspect of the shoulder, the limb being usually abducted and the muscles relaxed and taken unawares. The head of the humerus, thus brought to bear on the weakest part of the capsule, ruptures it and passes out through the rent. Dislocation is readily produced in an unconscious person, as for example in conducting artificial respiration in a patient suffering from opium poisoning.

Varieties.—Several varieties of dislocation are recognised, according to the position in which the head of the humerus finally rests (Fig. 128). The simplest of these is the *sub-glenoid* variety, in which the head rests on the long tendon of the triceps where it arises from the axillary border of the scapula just below the glenoid cavity. In almost all dislocations of the shoulder the head of the bone is at least momentarily in this position, but the sharp edge of the scapula and the rounded head are ill adapted to one another, and the position is not long maintained. The subsequent course taken by the humerus depends upon the nature and direction of the force, the position of the limb at the moment of injury, and the relative strength and capacity for effective action of the different groups of muscles acting upon the bone.

In the great majority of cases it passes forward and inward, and comes to lie against the anterior surface of the neck of the scapula, under cover of the tendons of origin of the biceps and coraco-brachialis muscles, constituting the *sub-coracoid dislocation*. Much less frequently it passes still farther in and lies under cover of the pectoralis minor and against the edge of the clavicle—the *sub-clavicular* variety. In rare cases the head passes backward and lies against the spine on the dorsum of the scapula, beneath the infraspinatus muscle—the *sub-spinous* variety. Other varieties are so rare that they do not call for special mention.

Clinical Features common to all Varieties.—Dislocations of the shoulder are commonest in adult males; in advanced life the proportion of female sufferers increases. They are usually attended with great pain, and there is often numbness of the limb due to pressure of the head of the bone upon the large nerve-trunks. There is sometimes considerable shock.

The patient inclines his head towards the injured side, and, while standing, the forearm is supported by the hand of the opposite side. The acromion process stands out prominently, the roundness of the shoulder giving place to a flattening or depression immediately below it, so that a straight-edge applied to the outer aspect of the limb touches both the acromion and the external condyle. The vertical circumference of the axilla is markedly increased. The head of the bone can usually be felt in its new position, and the axis of the humerus is correspondingly altered, the elbow being carried from the side—forward or backward according to the position of the head. The empty glenoid may sometimes be palpated from the axilla. In most cases, although not in all, the patient is unable at one and the same time to bring his elbow to the side and to place his hand upon the opposite shoulder (Dugas' symptom). Measurements of the length of the limb from acromion to external condyle are rarely of any diagnostic value.

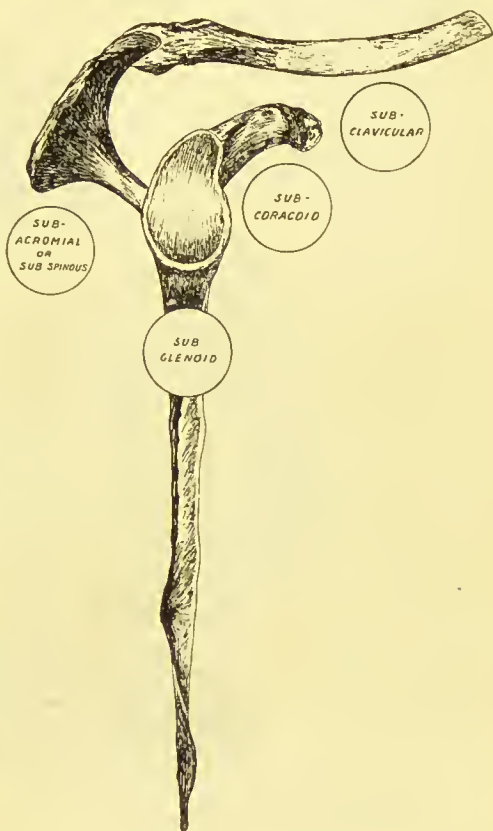


FIG. 128.—Diagram of most common varieties of Dislocation of the Shoulder.

The **sub-coracoid dislocation** (Fig. 129) is that most frequently met with. It usually results from hyper-abduction of the arm while the scapula is fixed, as in a fall on the inner side of the elbow when the arm is abducted from the side. The surgical neck of the humerus is then brought to bear upon the under aspect of the acromion, which forms a fulcrum, and the head of the bone is pressed against the inner and lower part of the capsule. In some cases muscular action produces this dislocation; it may also

result from force applied directly to the upper end of the humerus.

The head leaves the capsule through the rent made in its lower part, and, either from a continuation of the force or from contraction of the muscles inserted into the bicipital groove, particularly the great pectoral, passes inwards under cover of the biceps and coraco-brachialis till it comes to rest against the anterior surface of the neck of the scapula, just



FIG. 129.—Sub-coracoid Dislocation of Left Shoulder. Note flattening of shoulder, depression of axillary fold, and attitude of patient.

below the coracoid process. The anatomical neck of the humerus presses against the anterior edge of the glenoid, and there is frequently an *indentation fracture of the head of the humerus* where the two bones come into contact (F. M. Caird). The subscapularis is bruised or torn, the muscles inserted into the great tuberosity are greatly stretched, or the tuberosity itself may be avulsed, allowing the long tendon of the biceps to slip outwards, where it may form an impediment to reduction. The circumflex nerve is often bruised or torn, and the

head of the humerus is liable to press injuriously on the axillary nerves and vessels.

The *clinical features* common to all dislocations are prominent, although Dugas' symptom is not constant.

Treatment.—The guiding principle in the reduction of these dislocations is to make the head of the bone retrace the course it took in leaving the socket. The main obstacles to reduction being muscular contraction and the entanglement of the head with tendons, ligaments, or bony points, appropriate means must be taken to counteract each of these factors.

A general anæsthetic is an invaluable aid to reduction, and should be given unless there is some reason for withholding it. It is specially indicated in strong muscular subjects, and in nervous patients who do not bear pain well, and particularly when the dislocation has existed for a day or two. In quite recent cases, however, the surgeon may succeed in replacing the bone by taking advantage of a temporary faintness, or by engaging the patient's attention with other matters while he carries out the appropriate manipulations.

When an anæsthetic is employed, the patient should be laid on a mattress on the floor, or on a narrow, firm table; otherwise he should be seated on a chair.

Kocher's method is suitable for the great majority of cases of sub-coracoid dislocation. (1) The elbow is firmly pressed against the side, and the forearm flexed to a right angle. The surgeon grasps the wrist and elbow and firmly *rotates the humerus outward* (Fig. 131) till distinct resistance is felt and the deltoid becomes more prominent. In this way the rent in the lower part of the capsule is made to gape, and the head of the humerus rolls outwards till it lies opposite the opening, rotation taking place about the fixed point formed by the contact of the anatomical neck of the humerus with the anterior lip of the glenoid cavity (D. Waterston). (2) *The elbow is next carried forward, upward, and towards the middle line* (Fig. 126); the humerus acting as the long arm of a lever on the fulcrum furnished by the muscles inserted in the region of the surgical neck, the head, which forms the short arm of the lever, is carried backward, downward, and outward, and is thus directed towards the socket. (3) The humerus is now *rotated inward* by carrying the hand across the chest towards the opposite shoulder (Fig. 127). The anatomical neck of the humerus is thus disengaged from the edge of the glenoid, and the head is pulled into the socket by the tension of the surrounding muscles.



FIG. 130.—Sub-coracoid Dislocation of Humerus.

(Mr. Stiles' case. Radiogram by Dr. Edmund Price.)

A method of reduction has been formulated by A. G. Miller, which we have found to be quite as successful as Koehrer's method. The limb is grasped above the wrist and elbow, the forearm flexed to a right angle, and the upper arm abducted to the horizontal. While an assistant makes counter-extension and fixes the scapula, the surgeon gradually draws the arm out from the body till the head of the humerus is felt to pass outwards. The humerus is then rotated inwards by dropping the hand (Fig. 134), and the bone gradually glides into the socket.

In a certain number of cases reduction can be effected by

hyper-abduction of the shoulder with traction. The patient is laid upon a firm mattress, and the surgeon, seated behind him and placing his foot on the acromion, slowly and steadily extends the arm until it is raised well above the head. In some cases the head of the humerus spontaneously slips into its socket; in others it may be manipulated into position by pressure from the axilla. This method is restricted to

recent cases, as in those of long standing the axillary vessels are liable to be stretched or torn.

The method of reduction by traction on the arm with the heel in the axilla is only to be used when other measures have failed, as it depends for its success on sheer force.

After-Treatment.—After reduction, the part is gently massaged for ten or fifteen minutes, a layer of wool is placed in the axilla, the forearm is supported by a sling, and the arm fixed to the side by a circular bandage. Massage is carried out daily from the first, and movement of the shoulder in every direction except that of abduction may be commenced on the



FIG. 131.—Kocher's Method of reducing Sub-coracoid Dislocation—First Movement; External Rotation of Arm.

first or second day. The circular bandage may be dispensed with at the end of a week, and abduction movements commenced, and by the end of a month the patient should be advised to use the arm freely.

The **sub-clavicular dislocation** (Fig. 128) is to be looked upon as an exaggerated degree of the sub-coracoid rather than as a separate variety. It is produced by the same mechanism, but the violence is greater, and the damage to the soft parts more severe. The head passes farther upwards and inwards



FIG. 132. — Kocher's Method — Second Movement; Elbow carried forward, upward, and towards the Middle Line.



FIG. 133. — Kocher's Method — Third Movement; Inward Rotation of Arm.

under cover of the pectoralis minor, resting under the clavicle against the serratus magnus and chest wall. The symptoms are usually so marked that they leave no doubt as to the diagnosis. The outline of the head of the humerus in its abnormal position is visible through the skin, and the shortening of the limb is more marked than in the sub-coracoid variety. The treatment is the same as for sub-coracoid dislocation.

Sub-glenoid dislocation (Fig. 128) is less frequently met with than the sub-coracoid variety, and almost always results from forcible abduction of the arm. The head of the humerus passes out through a small rent in the lower and inner portion

of the capsule, and rests against the anterior edge of the triangular surface immediately below the glenoid cavity, supported behind by the long head of the triceps, and in front by the subscapularis muscle. It is readily felt in the axilla. All the tendons in relation to the upper end of the humerus are stretched or torn, and the great tuberosity is not infrequently avulsed. There is sometimes bruising of the circumflex nerve.

The projection of the acromion, the flattening of the deltoid, the increased depth of the axillary fold, and the abduction of the elbow are very marked; the arm is slightly lengthened,



FIG. 134.—Miller's Method of reducing Sub-coracoid Dislocation—Second Movement.

rotated out, and carried forward. It is reduced by the hyper-abduction method (p. 489).

Sub-spinous Dislocation.—Backward dislocation is usually termed sub-spinous, although in a considerable proportion of cases the head of the humerus does not pass beyond the root of the acromion process (*sub-acromial*) (Fig. 128). This dislocation is usually produced by a fall on the elbow, the arm being at the moment adducted and rotated in, so that the head of the humerus is pressed backwards and outwards against the capsule, which ruptures posteriorly. All the muscles attached to the upper end of the humerus are liable to be torn, and the

tuberosities are frequently avulsed. The long tendon of the biceps may slip from its position between the tuberosities, and prevent reduction or favour re-dislocation, necessitating an open operation.

In the milder cases the *clinical features* are not always well marked, and on account of the swelling this dislocation is apt to be overlooked. In addition to the ordinary symptoms, the shoulder is broadened, there is a marked hollow in front in which the coracoid projects, and the arm is held close to the side with the elbow directed forward. The head of the bone may be seen and felt in its abnormal position below the spine of the scapula.

Reduction can usually be effected by making traction on the arm with internal rotation, and pressing the head forward into position, while counter-pressure is made upon the acromion.

Prognosis.—The ultimate prognosis in dislocations of the shoulder should always be guarded. The circumflex nerve may be stretched or torn, and this may lead to atrophy of the deltoid; or other branches of the brachial plexus may be injured and the muscles they supply permanently weakened. In a certain number of cases traumatic neuritis has resulted in serious disability of the limb. The movements of the shoulder-joint may be restricted by cicatricial contraction of the torn portion of the capsule and of the damaged muscles. Recurrent dislocation may follow if abduction movements are permitted before repair of the capsule has had time to occur.

Dislocation of the Shoulder complicated with Fracture of the Upper End of the Humerus.—In these injuries the dislocation is almost always of the sub-coracoid variety, and the most common fractures by which it is complicated are those of the surgical neck, the anatomical neck, or the greater tuberosity. The most common cause is a fall directly on the shoulder, and it seems probable that the head of the bone is first dislocated, and, the force continuing to act, the upper end of the humerus is then broken; or the two lesions may be produced synchronously (Robert Jones).

When seen soon after the accident, the existence of the fracture of the humerus is liable to be overlooked, the condition being mistaken for dislocation alone, or for a fracture through the neck of the scapula. On careful examination under an anæsthetic, however, it is observed that not only is the head of the humerus absent from the glenoid cavity, but that it does not move with the rest of the bone, abnormal mobility and crepitus are recognised at the seat of fracture, and

the upper arm is shortened. The extravasation in the axilla is usually greater than that accompanying a simple dislocation, and the pain is more severe. A fracture through the neck of the scapula is readily recognised by the ease with which the deformity is reduced, and the way in which it at once recurs when the support is withdrawn. In many cases it is only by the aid of a radiogram that an accurate diagnosis can be made (Fig. 135).



FIG. 135.—Dislocation of Shoulder with Fracture of Neck of Humerus.
(Mr. Robert Jones' case. Radiogram by Dr. D. Morgan.)

Treatment.—Unless the dislocation is reduced at once, the movements of the arm are certain to be seriously restricted, and painful pressure effects from excess of callus are liable to ensue. An attempt should first be made, under anæsthesia, to replace the head in its socket, by making extension on the arm in the hyper-abducted (vertical) position, and manipulating the upper fragment from the axilla.

On no account should the lower fragment be employed as a lever in attempting reduction. When reduction by external

manipulation fails, the upper fragment should be exposed by an incision over its outer aspect, and made to return to the socket by using Arbuthnot Lane's levers or M'Burney's hook, or a long steel pin may be inserted into the fragment to give the necessary leverage.

Reduction having been accomplished, the fracture is adjusted in the usual way, advantage being taken of the open wound, if necessary, to fix the fragments together by wires or plates. The best position in which to fix the limb is that of abduction at a right angle. Massage and movement should be commenced early to prevent stiffness of the joint.

When it is found impossible to reduce the dislocation, it is usually advisable to remove the upper fragment.

The method of allowing the fracture to unite without reducing the dislocation, and then attempting reduction, usually results in re-breaking the bone, or else in failure to replace the head in the socket, and has nothing to recommend it.

Old-standing Dislocations of the Shoulder.—It is impossible to lay down definite rules as to the date after which it is inadvisable to attempt reduction of an old-standing dislocation of the shoulder by manipulation. Experience of a hundred cases in Bruns' clinic led Finckh to conclude that, provided there are no complications, reduction can generally be effected within four weeks of the accident; that within nine weeks the prospect of succeeding is fairly good; but that beyond that time reduction is exceptional.

The patient is anæsthetised, and all adhesions broken down by free, yet gentle movement of the limb. The appropriate manipulations for the particular dislocation are then carried out, care being taken that no undue force is employed, as the humerus is liable to be broken. If these are not successful, they should be repeated at intervals of two or three days, as it is frequently found that reduction is successfully effected on a second or third attempt.

Should manipulative measures fail, it may be advisable to have recourse to operation if the age of the patient and his general health warrant it, and if the condition of the limb is interfering with his occupation, or involves serious disability. If operation is deemed advisable, a few days should be allowed to elapse to permit of the parts recovering from the effects of the manipulations. The joint is freely exposed, the capsule divided, the head of the bone freed and returned to the glenoid cavity. It is sometimes so difficult to replace the head of the

bone that it is necessary to reset it and aim at the formation of a new joint, an operation which usually yields satisfactory results.

Habitual or Recurrent Dislocation.—Cases are occasionally met with in which the shoulder-joint shows a marked tendency to be dislocated from causes altogether insufficient to produce displacement under ordinary circumstances. This condition is usually met with in young women, and, in some cases at least, appears to be due to too early and too free movement of the joint after an ordinary dislocation, so that the capsule is stretched and remains lax. In some cases it would appear that the liability to dislocation is due to some structural defect in the joint, and under these conditions both sides are sometimes affected, and the accident is not attended with the usual pain and disability either at the time or after reduction. The facility and frequency with which dislocation recurs render the limb comparatively useless, and may seriously incapacitate the patient.

The *treatment* consists in preventing the patient making the particular movements which tend to produce the dislocation. These are chiefly movements of hyper-abduction and overhead movements, such as are made, for example, in swimming or in arranging the hair. We have found an apparatus consisting of a belt applied around the thorax, and fixed to another around the upper arm by a band which passes above the axillary fold of the dress, useful in restraining these movements. If necessary, massage, electricity, and movements against resistance are employed to strengthen the weak muscles. If, after a prolonged trial, these measures fail, it may be advisable to tighten up the lax capsule by drawing it into folds with a series of catgut sutures, after which the joint is kept at rest for three or four weeks. The subscapularis may be detached from its insertion into the humerus and united to the deltoid (Openshaw).

The condition is also met with in epileptics; and it is generally found that the head of the bone is deficient, as a result either of fracture or disease; that the muscles which naturally support the joint are atrophied or torn; and that the capsule is unduly lax.

Sprains of the shoulder-joint are comparatively rare, because of the wide range of movement of which it is capable. The region of the shoulder becomes swollen and tender to pressure, the point of maximum tenderness being over the front of the joint, just below the acromion process; pain is elicited also when the ligaments or tendons are put upon the stretch.

Contusions of the region of the shoulder, on the other hand, are exceedingly common. In most cases it is merely the deltoid muscle and the subcutaneous tissue over it that are bruised, but sometimes a hæmatoma forms either in the muscle or in the sub-deltoid bursa (p. 428). There is pain on moving the limb, and the patient may be unable to abduct the arm at the shoulder-joint. Under treatment by massage and movement, the symptoms usually pass off completely in two or three weeks.

In other cases, the cords of the brachial plexus above the clavicle are stretched, or the circumflex nerve is bruised, and these injuries are liable to be followed by prolonged pain, loss of abduction, and stiffness in the upper arm. The deltoid frequently undergoes considerable atrophy, and there is severe neuralgic pain in the circumflex nerve, especially marked in the region of the insertion of the deltoid.

In addition to maintaining the limb in the abducted position, it is necessary to keep up the nutrition of the muscles by massage and electricity.

FRACTURES OF THE SCAPULA

Fractures of the scapula may implicate the body, the surgical neck, the acromion, or the coracoid process. They are rarely compound.

Fracture of the Body.—Considering its exposed position, the body of the scapula is comparatively seldom fractured, doubtless because of its mobility, and the support it receives from the elastic ribs and soft muscular cushion on which it lies. Apart from gun-shot injuries, it is most frequently broken by a severe blow or crush. The scapula presents two natural arches—one longitudinal, the other transverse—and when the bone is crushed or struck, the force produces fracture by undoing its curves (E. H. Bennett). A main fissure usually runs transversely across the infra-spinous fossa, and secondary cracks radiate from it (Fig. 136). In other cases the line of the primary fracture is longitudinal, passing through the spine and involving both fossæ.

The *clinical features* are often obscured by swelling of the overlying soft parts. Crepitus may sometimes be elicited by placing one hand firmly over the bone, and with the other moving the arm and shoulder. When the spine is implicated, the fragments may be grasped and made to move one upon another. The displacement, which usually consists in

overlapping of the fragments—although sometimes they are drawn apart—is partly due to the action of the serratus magnus and teres major muscles, and partly depends on the direction of the force. Movement is restricted and painful. Osseous union usually takes place rapidly, and although displacement often persists, the function of the limb is unimpaired.

Treatment.—As these fractures are usually complicated by other injuries, especially of the thorax, and are accompanied by severe shock, it is necessary to confine the patient to bed. It is usually sufficient to fix the arm and shoulder to the chest wall by a firm binder, in the position which admits of the most complete apposition of fragments. This retentive apparatus is employed for about three weeks, after which the patient is allowed to use his arm. The bandages are removed daily to admit of massage.

Fraeture of the surgical neck of the scapula, although a rare accident, is of considerable clinical importance, as it is liable to be mistaken for dislocation of the shoulder. The line of fracture runs through the supra-scapular notch, downwards and outwards to the lower margin of the glenoid, so that the glenoid and the coracoid process are separated from the rest of the bone.



FIG. 136.—Transverse Fracture of Scapula, with fissures radiating into spinous process and dorsum.

The coraco-acromial and coraco-clavicular ligaments are usually torn, and the detached fragment, along with the head of the humerus, sinks into the axilla, causing a flattening of the shoulder, and leaving a depression below the projecting acromion. The arm is lengthened by about an inch. By supporting the arm the deformity is at once reduced, but recurs as soon as the support is withdrawn. Crepitus is usually detected on carrying out this manipulation; and the coracoid process is found to move with the arm and not with the scapula. By these tests, and by the X-rays, this injury is distinguished from a dislocation.

A partial fracture carrying away the lower part of the *glenoid cavity* sometimes simulates a sub-glenoid dislocation. This is, however, a rare injury.

The *treatment* consists in bracing back the shoulders and supporting the elbow, and this is most satisfactorily done by a body bandage and sling for the elbow as for fracture of the middle third of the clavicle (p. 479). Passive movement and massage are employed from the first.

Fracture of the acromion process may result from a blow or fall on the shoulder. It is often overlooked on account of the swelling resulting from bruising of soft parts, and the absence of marked displacement. On palpation, crepitus and an irregularity at the seat of fracture may sometimes be detected. The shoulder is slightly flattened, and abduction of the arm is difficult. In rare cases the fracture passes into the acromio-clavicular joint, and is associated with dislocation of the clavicle.

In connection with this fracture, reference must be made to a condition frequently met with, in which the epiphysial portion of the acromion is found to be separate from the body of the process—*separate acromion*. This is by some (Symington, Hamilton) looked upon as a want of union of the epiphysis, but the weight of evidence seems to prove that it is rather of the nature of an un-united fracture at this level, even when, as sometimes happens, it is bilateral (Struthers, Arbuthnot Lane).

Between the fourteenth and twenty-second years a true *separation of the epiphysis* may be met with, but it is seldom possible to make a positive diagnosis of this injury. As is the case in all fractures of the acromion, bony union seldom takes place.

The *treatment* is the same as for fracture of the outer end of the clavicle.

Fracture of the coracoid process is exceedingly rare. It may result from direct violence, such as the recoil of a gun, but is more often an accompaniment of dislocation of the shoulder or of the outer end of the clavicle upward. As the coraco-clavicular ligaments usually remain intact, there is no displacement; but when these are torn the coracoid is dragged downwards and outwards by the combined action of the pectoralis minor, biceps, and coraco-brachialis muscles. Crepitus may be elicited on moving the fragment. *Separation of the epiphysial portion* of the coracoid may occur up to the seventeenth year.

The *treatment* consists in placing the arm across the front of the chest, to relax the muscles causing the displacement, and retaining it in that position by a sling and roller bandage.

FRACTURES OF THE UPPER END OF THE HUMERUS

It is most convenient to study fractures of the upper end of the humerus in the following order: (1) fracture of the surgical-neck; (2) separation of the epiphysis; (3) fracture of head, anatomical neck, or tuberosities.

Fracture of the Surgical Neck.—The surgical neck of the humerus extends from the level of the epiphysial junction to the insertion of the pectoralis major and teres major muscles, and it is within these limits that most fractures of the upper end of the bone occur. This fracture is most common in adults, and usually follows direct violence applied to the shoulder, but may result from a fall on the hand or elbow, or from violent muscular action, as, for example, in throwing a stone. It is usually transverse, and there is often little or no displacement, the fragments being retained in position by the long tendon of the biceps and the long head of the triceps.



FIG. 137. — Fracture of Surgical Neck of Humerus, united with Angular Displacement.

When the fracture is oblique, the fragments are often comminuted, and sometimes impacted. The displacement of the upper fragment seems to depend upon the attitude of the limb at the moment of fracture. When the upper arm is approximated to the side, the upper fragment retains its vertical position, but is slightly rotated outwards by the muscles



FIG. 138.—Impacted Fracture of Neck of Humerus, in man æt. 75.

(Mr. Stiles' case. Radiogram by Dr. Edmund Price.)

inserted into the greater tuberosity, while the lower fragment is drawn upwards and inwards towards the coracoid process by the muscles inserted into the bicipital groove and the longitudinal muscles of the upper arm, and can be felt in the axilla. The elbow points outwards and backwards, and the upper arm is shortened. The shoulder retains its rotundity, but there is a slight hollow some distance below the acromion.

On grasping the elbow and moving the shaft, it is found that the head and tuberosities do not move with it, and unnatural mobility and erepitus at the seat of fracture may be detected. When the upper arm is abducted at the moment of fracture, the upper fragment is retained in that position by the external rotator and abductor muscles inserted into it, while the lower fragment passes upwards and inwards.

Although there is sometimes overlapping and broadening after union, beyond some limitation of the range of abduction, the usefulness of the limb is seldom impaired.

Treatment.—Massage, by allaying spasm of the muscles, soon overcomes the moderate amount of displacement which is usually met with. Further, the skin

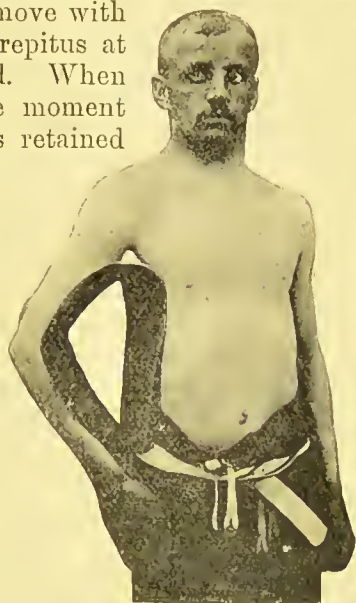


FIG. 139.—Wedge shaped Splint of Poroplastic for treatment of Fractures at Upper End of Humerus in abducted position. To avoid obscuring the splint the padding and bandages have been omitted.

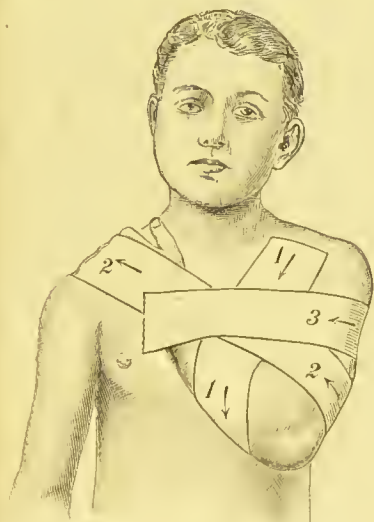


FIG. 140.—Chiene's Bandage for Fracture of Surgical Neck of Humerus. The turns fixing the arm to the chest are not figured.

surfaces of the axilla having been separated by a thin layer of cotton wool, a sling is applied to support the wrist, and the arm is bound to the side by a body bandage.

In comminuted fractures and those with very marked displacement, a general anæsthetic may be required to ensure accurate reduction; and to maintain the fragments in apposition, and to avoid any limitation of abduction after union, the limb may be fixed in the position of abduction at a right angle, extension with weight and pulley over the side of the bed being applied,

if necessary, to maintain this attitude. After a week or ten days the patient is allowed up, wearing a triangular splint, such as Middeldorpf's, which consists of a double inclined plane, the base of which is fixed to the patient's side, while the injured arm rests on the other two sides of the triangle (Fig. 139). Massage and movement are employed daily.

Another method of fixation, described by Professor Chiene, is as follows: "Lay the arm across the chest, and the hand over the opposite shoulder. The tail of a bandage is then placed on the shoulder of the injured arm and carried down the upper arm, round beneath the elbow and up along the back of the forearm to the opposite shoulder, then across the back to below the deltoid of the injured arm, round the upper arm to the elbow, repeating as often as necessary. Last of all, fix the arm to the chest by circular turns" (Fig. 140).



FIG. 141.—Upper Epiphysis of Humerus.
(After Poland.)

Should these measures fail, the fracture may be exposed by an incision carried along the anterior border of the deltoid, and the ends mechanically fixed, after which the limb is put up in the abducted position for three or four weeks. Massage is commenced on the second or third day. Union is usually complete in about four weeks.

Separation of Epiphysis.—The upper epiphysis of the humerus includes the head, both tuberosities, and the upper fourth of the bicipital groove (Fig. 141). On its under aspect is a cup-like depression into which the central pyramidal-shaped portion of the diaphysis fits. This epiphysis unites about the twenty-first year.

Traumatic separation is met with chiefly between the fifth and fifteenth years, and is most common in boys. It usually results from forcible traction of the arm upwards and outwards, as in lifting a child by the upper arm, or from direct violence, but may be caused by a fall on the outer side of the elbow.

The epiphysis, especially in young children, may be separated without being displaced, or the displacement may be incomplete. When the epiphysis is completely separated from the shaft,

the clinical features closely resemble those of fracture of the surgical neck, and the diagnosis is made by a consideration of the age of the patient, and the muffled character of the crepitus, when it can be elicited. The upper end of the diaphysis forms a projecting ridge which may be felt below and in front of the acromion. The diagnosis can usually be established by the use of the X-rays. Dislocation is rare at the age when separation of the epiphysis occurs.

Reduction is often difficult on account of the periosteum and other soft tissues getting between the fragments, and on account of the small size of the upper fragment. Union almost invariably results, but the growth of the limb may be seriously interfered with (Fig. 142), and its shape is sometimes much altered, especially when the injury occurs at an early age and its nature is overlooked.

Treatment.—This injury is treated on the same general lines as fracture of the surgical neck. General anæsthesia is almost always necessary to secure satisfactory reduction, and retention is sometimes only possible if the patient is confined to bed with the upper arm fixed in the fully abducted position by means a plaster-of-Paris bandage. Operative treatment is more frequently called for than in fracture of the surgical neck, and in some cases it has even been found necessary to remove the epiphysis.

Fractures of the Head, Anatomical Neck, and Tuberosities of Humerus.—These fractures are met with as accompaniments of dislocation of the shoulder, and as results of gun-shot injuries, blows, or falls.

In sub-coracoid dislocation the *head* of the humerus is often indented by coming in contact with the anterior edge of the glenoid cavity.

The *anatomical neck* may be fractured in an old person by a direct blow on the shoulder. In a few cases the fracture is entirely intra-capsular, the head of the bone remaining loose in the cavity of the joint. As a rule, however, the fracture passes through the anatomical neck only on the inner side, diverging into the tuberosities externally. In some cases there is impaction, and in others comminution of the fragments. The use of the X-rays has shown that in many cases in which prolonged stiffness has followed a severe blow over the shoulder, there has been a fracture of the anatomical neck.

The *tuberosities* may be implicated in other fractures in this region and in dislocation of the shoulder; and either of them may be separated by muscular contraction or by direct violence.

Clinically all these injuries are difficult to diagnose with accuracy, and, without the use of the X-rays, it is impossible in many cases to go further than to say that a fracture exists above the level of the surgical neck. Fracture of the anatomical neck is attended with little deformity beyond slight flattening of the shoulder and sometimes slight shortening of the upper arm.

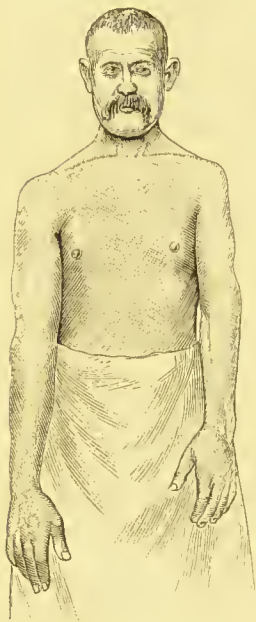


FIG. 142.—Shortening of Upper Arm from Injury to Upper Epiphysis in childhood.

When the great tuberosity is torn off, considerable antero-posterior broadening of the shoulder may be recognised, by grasping the region of the tuberosities between the fingers and thumb. Crepitus can be elicited on rotating the humerus. At the same time it will be recognised that the tuberosity does not move with the shaft. Firm union, with considerable formation of callus and some broadening of the shoulder, usually results, but the usefulness of the joint is not necessarily impaired. There may, however, be prolonged stiffness and impaired movement from the adhesions; or pain and crackling in the joint may result from arthritic changes like those of arthritis deformans.

Treatment.—These fractures are treated on the same lines as fracture of the surgical neck of the humerus. Massage and movement should be commenced at once. Operative treatment is seldom called for.

The combination of fracture of the upper end of the humerus with dislocation of the shoulder has already been referred to.

FRACTURE OF THE SHAFT OF THE HUMERUS

Fractures occurring in the shaft of the humerus, between the surgical neck and the base of the condyles, may, for convenience of description, be divided into those above, and those below, the level of the deltoid insertion—the majority being in the latter situation.

Direct violence is the most common cause of these fractures, but they may occur from a fall on the elbow or hand; and a considerable number of cases are on record where the bone has been broken by muscular action—as in throwing a cricket-

ball. Twisting forms of violence may produce spiral fractures (Fig. 110).

The fracture is usually transverse in children and in cases in which it is due to muscular action. In adults, when due to external violence, on the other hand, it is usually oblique, the fragments overriding one another and causing shortening of the limb. The displacement depends largely on the direction of the force and the line of fracture, but to a certain extent also on the action of muscles attached to the fragments. Thus, in fractures above the insertion of the deltoid the upper fragment is usually dragged inward by the muscles inserted into the bicipital groove, while the lower is tilted out by the deltoid. When the break is below the deltoid insertion the displacement of the fragments is reversed. Undue mobility, deformity, crepitus, and the other signs of fracture are evident, and the patient himself usually recognises that the bone is broken. The nerve-trunks in the upper arm, particularly the median, ulnar, and musculo-spiral, are apt to be damaged in these injuries. In fractures of the lower part of the shaft the musculo-spiral nerve is specially liable to be implicated. This may occur at the time of the injury, the nerve being contused by the force causing the fracture, or pressed upon by one or other of the fragments, or its fibres may be partly or completely torn across. When there is evidence of nerve injury, the practitioner should draw the attention of the patient to it before applying splints, and so guard himself against actions for malpraxis should paralysis of the muscles ensue. Later, the nerve may become involved in callus, or be damaged by the pressure of ill-fitting splints. Weakness or paralysis of the extensors of the wrist and hand results, giving rise to the characteristic "wrist-drop." The actions of the muscles should always be tested before applying splints, and each time the apparatus is removed or readjusted, to ensure that no undue pressure is being exerted on the nerves.

Union takes place in from four to six weeks in adults, and in from three to four weeks in children. Delayed union, or want of union and the formation of a false-joint, is more common in fractures of the middle of the shaft of the humerus than in any other long bone. This is largely due to the frequency with which soft structures come to lie between the fragments. Arrest of growth in the bone from injury to the nutrient artery is also said to have occurred.

Treatment.—In treating a fracture of the shaft of the humerus, the possibility of non-union should always be kept in

mind. Reduction is effected, by the aid of a general anæsthetic if necessary, care being taken that no soft tissue intervenes between the fragments; the appearances seen with the X-rays may yield information on this point, a clear space persisting between the fragments even when they are apparently in apposition. The local splint to control the fracture is applied in the form of a ferrule surrounding the bone. This may consist of several short, narrow pieces of wood secured by a bandage or strap and buckle; or better, of two pieces of Gooch splinting out as in Fig. 143, special provision being made for avoiding pressure on the condyles.

Reduction by manipulation is not always necessary. Displacement is often maintained by the muscular spasm. Massage will allay these spasms after a few daily sittings, and

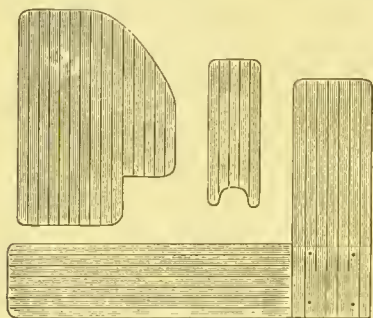


FIG. 143.—Gooch Splints for Fracture of Shaft of Humerus; and rectangular splint to secure elbow.

the fragments will of themselves assume correct alignment with little tendency to redisplacement. At any rate, after a few sittings of massage, reduction by manipulation becomes easy, and retentive apparatus less necessary. Excellent results have been obtained without rigid splints.

The elbow is flexed at a right angle, and the forearm is supported in a sling midway between pronation and supination.

For a few days the limb is bound to the chest by a wide roller bandage.

The splints are removed daily to admit of massage and movement being carried out, and while the splints are off the patient is allowed to exercise the fingers and wrist. If, at the end of four or five weeks, osseous union has not occurred, the reparative process may be hastened by inducing venous congestion by Bier's method.

In oblique fractures, when there is difficulty in preventing overriding and redisplacement, the fragments may be exposed by incision, and fixed together by mechanical means.

When there is evidence that the musculo-spiral nerve has been injured, and no sign of improvement appears within three or four days of the accident, operative interference is indicated. An incision is made on the outer side of the arm, and the nerve exposed and freed from pressure, or stitched, as

may be necessary. The opportunity should also be taken of dealing with the fracture.

In cases of *un-united fracture*, a vertical or semilunar incision is made over the outer aspect of the bone, and the muscles separated from one another till the fracture is exposed, care being taken to avoid injuring the musculo-spiral nerve. The fibrous tissue is removed from the ends of the bone, and the rawed surfaces fixed in apposition by pegs, plates, or wires. The wound is then closed, and appropriate retentive apparatus applied. As soon as the wound has healed, massage and movement are employed.

CHAPTER XXIII

INJURIES IN THE REGION OF THE ELBOW AND FOREARM

Surgical Anatomy—Examination of injured elbow—FRACTURES OF LOWER END OF HUMERUS: *Supra-condylar; Inter-condylar; Separation of epiphysis; Fracture of either condyle alone; Fracture of either epicondyle alone*—FRACTURES OF UPPER END OF ULNA: *Olecranon; Coronoid*—FRACTURES OF UPPER END OF RADIUS: *Head; Neck; Separation of epiphysis*—DISLOCATIONS OF ELBOW: *Both bones; Ulna alone; Radius alone*—FRACTURES OF FOREARM: *Both bones; Radius alone; Ulna alone.*

THE injuries met with in the region of the elbow-joint include the various fractures of the lower end of the humerus, and upper ends of the bones of the forearm, including the olecranon process; and dislocations and sprains of the elbow-joint. The differential diagnosis is often exceedingly difficult, on account of the great swelling and tension which rapidly supervene on most of these injuries, the pain caused by manipulating the parts, and the difficulty of determining whether movement is taking place *at* the joint or *near* it.

Surgical Anatomy.—The internal epicondyle of the humerus is more readily felt through the skin than the external. The two epicondyles are practically on the same level, and a line joining them behind passes just above the tip of the olecranon process when the arm is fully extended. On flexing the joint, the tip of the olecranon gradually passes to the distal side of this line, and when the joint is fully flexed the tip of the olecranon is found to have passed through half a circle. The head of the radius can be felt to rotate in the dimple on the back of the elbow just below the external condyle. The coronoid process may be detected on making deep pressure in the hollow in front of the joint. As the line of the radio-humeral joint is horizontal, while that of the ulno-humeral joint slopes obliquely downwards, the upper arm forms with the fully extended and supinated forearm an obtuse angle, opening outward—the “carrying angle.” This angle is usually more marked in women, in harmony with the greater width of the female pelvis. The ulnar nerve lies in the hollow between the olecranon and the internal condyle, and the median nerve passes over the front of the joint, with the brachial

artery and biceps tendon to its outer side. The musculo-spiral nerve divides into its radial and posterior interosseous branches at the level of the outer condyle.

In *examining an injured elbow*, the thumb and middle finger are placed respectively on the two epicondyles, while the index locates the olecranon and traces its movements on flexion and extension of the joint. The movements of the head of the radius are best detected by pressing the thumb of one hand into the depression below the external condyle, while movements of pronation and supination are carried out by the other hand. The uninjured limb should always be examined for purposes of comparison.

In injuries about the elbow much aid in diagnosis is usually obtained by the use of the X-rays; but in young children it is sometimes impossible, even with excellent pictures, to make an accurate diagnosis by means of radiograms (Robert Jones). In cases of suspected fracture, a radiogram should be taken with the back of the limb resting on the sensitive plate, the forearm being extended and supinated. If a dislocation is suspected and a lateral view is desired, the arm should be placed on its inner side. In obscure cases it is useful to take radiograms of the healthy limb in the same position.

FRACTURES OF THE LOWER END OF THE HUMERUS

The following fractures occur at the lower end of the humerus: (1) supra-condylar fracture; (2) inter-condylar fracture; (3) separation of epiphyses; (4) fracture of either condyle alone; and (5) fracture of either epicondyle alone.

All these injuries are common in children, and may result from a direct fall or blow upon the elbow, or from a fall on the outstretched hand, especially when at the same time the joints are forcibly moved beyond their physiological limits, more particularly in the direction of pronation or abduction. While it is generally easy to diagnose the existence of a fracture, it is often exceedingly difficult to determine its exact nature. Although the ulnar and median nerves are liable to be injured in almost any of these fractures, they suffer much less frequently than might be expected.

Ankylosis, or, more frequently, locking of the joint, is a common sequel to many of these injuries. This is explained by the difficulty of effecting complete reduction, and by the wide separation of periosteum which often occurs, favouring the production of an excessive amount of new bone, particularly in young subjects.

The **supra-condylar** fracture usually results from a fall on the outstretched hand with the forearm partly flexed, from a direct blow, or from a twisting form of violence. The line of fracture is generally transverse, or but slightly oblique from behind



FIG. 144.—Radiogram of Supra-condylar Fracture of Humerus, in a child *et.* 7.

downwards and forwards, so that the lower fragment is forced backward together with the bones of the forearm, simulating backward dislocation of the elbow; the lower end of the upper fragment lies in front.

Clinical Features.—The elbow is flexed at an angle of 120° or 130° , and the forearm, held semi-pronated, is supported by the other hand. Around the seat of fracture great swelling rapidly ensues. The olecranon projects behind, but the mutual relations of the bony points of the elbow are unaltered. The lower end of the upper fragment may be felt in front above the level of the joint, as a rough and sharp projection, and this sometimes pierces the soft parts and renders the fracture compound. The joint movements are normal, but unnatural mobility may be detected above the level of the joint. Crepitus and localised tenderness may be elicited. The displacement is readily reduced by manipulation, but is usually reproduced when the support is withdrawn. The upper arm is shortened to the extent of about half an inch.

In rare cases the obliquity of the fracture is downward and backward, and the lower fragment is displaced forward.

The *inter-condylar* fracture is a combination of the supra-condylar with a vertical split running through the articular surface, and so implicating the joint (Fig. 145). The condyles are thus separated from one another, as well as from the shaft, by a T- or Y-shaped cleft. As such fractures usually result from severe forms of direct violence, they are often comminuted and compound. In addition to the signs of supra-condylar fracture, the cavity of the joint is filled with blood. The condyles may be felt to move upon one another, and coarse crepitus, which has been likened to the feeling of a bag of beans, may be elicited if the fragments are comminuted.

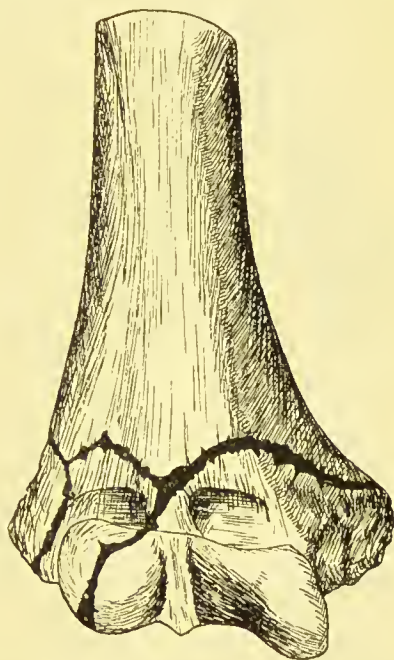


FIG. 145.—Inter-condylar Fracture of Lower End of Humerus, from a crush between buffers, in a boy *æt.* 19.

Separation of the lower epiphysis (Figs. 146, 147) of the humerus is met with in children of three or four years of age, but it may occur up to the thirteenth or fourteenth year. The more common lesion, however, is a combination of separated epiphysis with fracture, and this lesion is produced by the same forms of violence as cause supra-condylar fracture. If the periosteum is not torn, there is little or no displacement, but as a rule the clinical features closely resemble those of transverse fractures above the condyles, or of dislocation of the elbow. In separation of the epiphysis there is a peculiar deformity of the posterior aspect of the joint, consisting of two projections—one the olecranon process, and the other the prominent capitulum with a

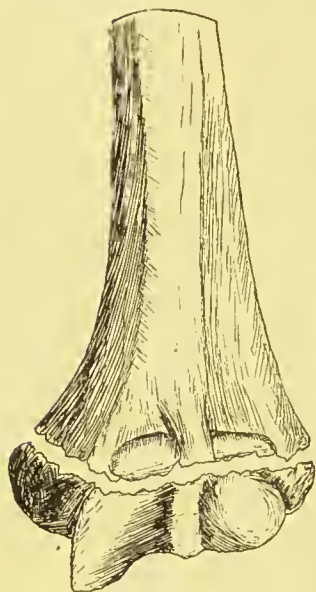


FIG. 146.—Complete Separation of Lower Epiphysis of Humerus.

scale of cartilage which it carries with it from the external condyle (R. W. Smith and E. H. Bennett). The end of the diaphysis may be palpated through the skin in front. Muffled crepitus can usually be elicited, and there is pain on pressing the segments against one another. Sometimes the separation is *com-pound*, the diaphysis protruding through the skin.

Union takes place more rapidly than in true fracture, but, owing to the excessive formation of callus from the torn periosteum in front of the joint, full flexion is often interfered with. If the displaced epiphysis is imperfectly reduced, serious interference with the function of the elbow is liable to ensue, and may call for operative treatment.



FIG. 147.—Partial Separation of Lower End of Humerus, with fracture of Diaphysis.

Fracture of either Condyle alone.—The external condyle or trochlea is more frequently separated from the rest of the bone than is the internal or capitellum (Robert Jones). In either, the size of the fragment varies, but the line of fracture is partly extra-capsular and partly intra-capsular, so that the joint is always involved. Pain, crepitus, and the other signs of fracture are present. As the ligaments of the joint are not as a rule torn, there is little or no immediate displacement of the fragment. Secondary displacement is liable to occur, however, during the process of union, producing alterations in the "carrying angle" of the limb — *cubitus varus* or *cubitus valgus* (Figs. 148, 149).

Fracture of Epicondyles.—Fracture of the *external epicondyle* alone is so rare that it need only be mentioned.

The *internal epicondyle* may be chipped off by a fall on the edge of a table or kerb-stone, or it may be forcibly avulsed by traction through the internal lateral ligament, as an accompaniment of dislocation. It is usually displaced downwards and forwards by the flexor muscles attached to it, and may thus come to exert pressure on the ulnar nerve. The fragment may be grasped and made to move on the shaft, producing crepitus. Fibrous union is the usual result.

Up to the age of seventeen or eighteen the epiphysis of the epicondyle may be separated.

Treatment of Fractures in region of Elbow.—The administration of a general anæsthetic is a valuable aid to accurate reduction and fixation of fractures in this region. Much discussion has taken place as to the best position in which to treat these fractures, and the consensus of opinion is in favour of full flexion at the elbow with supination. In this view clinical experience is supported by the evidence afforded by the Röntgen rays, as in no other



FIG. 148.—Cubitus Varus of Left Arm resulting from Fracture of Internal Condyle of Humerus in childhood. Note imperfect development of upper arm.

position can the fragments be brought into such accurate apposition.

The *supra-condylar fracture* is reduced by first extending the elbow to free the lower fragment from the triceps, and then, while making traction through the forearm, manipulating the fragments into position, and finally flexing the elbow to an acute angle and supinating the forearm. In this way the triceps is put upon the stretch and forms a natural posterior splint. A layer of wadding is placed in the bend of the elbow

to separate the apposed skin surfaces, the arm placed in a sling so arranged as to support the elbow, and fixed to the side by a body bandage. This position is maintained for three or four weeks, with daily massage and movement. The last movement to be attempted is that of complete extension. Operative treatment is rarely called for.

Separation of the epiphysis and fracture of the internal epicondyle are treated on the same lines as supra-condylar fracture.

T- or Y-shaped fractures and fractures of the condyles, inasmuch as they implicate the articular surfaces, present greater difficulties in treatment, but they are treated on the same lines as the supra-condylar. In young subjects whose occupation entails free movement of the elbow-joint, it is sometimes advisable to expose the fracture by operation and secure the fragments



FIG. 149.—Cubitus Valgus of Right Arm resulting from Fracture of External Condyle in childhood. Note imperfect development of upper arm.

in position. The details of the operation vary in different cases, and depend upon the line of obliquity of the fracture, and the disposition of the individual fragments, points which may usually be determined by the use of the X-rays. In performing the operation, care must be taken to disturb the periosteum as little as possible, lest the nutrition of the fragments be interfered with.

Operative interference is sometimes necessary for ankylosis or locking of the joint after the fracture is united, or to relieve the ulnar nerve when it is involved in callus.

FRACTURES OF THE UPPER END OF THE ULNA

Fracture of the olecranon process is a comparatively common injury in adults. It usually follows a fall on the flexed elbow, and is believed to result from the direct impact, supplemented by the traction of the triceps muscle. In a few cases it has been produced by muscular action alone. The line of fracture usually passes through the tip of the process, less frequently through its middle, and but rarely through the base. It may be transverse, oblique, T- or V-shaped, but is rarely comminuted or compound (Fig. 150).

Clinical Features.—As the fracture almost invariably implicates the articular surface, there is considerable swelling from effusion of blood into the joint. The power of extending the forearm is impaired, and other symptoms of fracture are present. The amount of displacement depends upon the level of the fracture, and the extent to which the aponeurotic expansion of the triceps is torn. As the fracture is usually near the tip, the displacement is generally comparatively slight, the prolongation of the fibres of insertion of the triceps on to the lateral and posterior parts of the process holding the small fragment in position (Fig. 150). When the line of fracture is nearer the base, however, the contraction of the triceps tends to separate the fragments widely (Fig. 151), and a distant gap, which is increased on flexing the elbow, may often be felt between them, and if the elbow is passively extended, the fragments may be brought into apposition, and crepitus elicited.

When there is little displacement, bony union may result, but in many cases the fragments are united only by fibrous tissue. The upper fragment sometimes forms attachments to the shaft of the humerus, and this leads to stretching of the fibrous band between the fragments and to marked wasting of the triceps.

Separation of the olecranon *epiphysis* is one of the rarest forms of epiphysial detachment (Poland). When the epiphysis is displaced upwards and unites in this position, it may interfere with complete extension of the elbow.



FIG. 150.—T-shaped Fracture of Olecranon Process.

Treatment.—It would appear that too much stress has hitherto been laid on the necessity of bringing the fragments into perfect apposition, and too little attention paid to the importance of massage and movement in maintaining the functions of the muscles and joint.

Massage and movements are carried out from the first, and the forearm is supported in a sling. Full flexion is the last



FIG. 151.—Radiogram of Fracture of Olecranon Process, showing marked degree of displacement.

(Mr. Robert Jones' case. Radiogram by Dr. D. Morgan.)

movement to be attempted. In carrying out the movements, the tip of the olecranon is pressed down with the thumb, so that it is obliged to follow the movements of the ulna, and is prevented from adhering to the humerus.

It was formerly the practice to have the arm almost, but not quite, fully extended, and a Gooch splint, extending from the lower border of the axilla to the finger-tips, and cut to the

shape of the extended limb (Fig. 152), applied anteriorly and fixed in position by a bandage, the region of the elbow being covered by a convergent spica.

Operative Treatment.—Operative treatment may be had recourse to, particularly in cases in which there is wide separation of the fragments. It is still an open question, however, whether the results are better than those obtained by non-operative measures.

A semilunar incision with its base above the tip of the olecranon is carried through the skin and fascia. The fracture is exposed, the joint cavity opened up and cleared of clots, and silver-wire sutures passed through the fragments without encroaching upon the articular cartilage. The limb is fixed with the elbow-joint in the position of almost complete extension. Movement may be commenced at the end of a week, the angle at which the joint is fixed being changed morning and evening. During the day the flexed position should be maintained and the arm carried in a sling; during the night the limb is fixed to a pillow in the extended position. The patient is allowed to use the joint cautiously within a fortnight.

Old-standing Fractures.—When firm union fails to take place, the interval between the fragments tends to increase by the contraction of the triceps gradually stretching the intermediate fibrous tissue, so that a wide gap comes to separate the fragments. If the function of the limb is impaired, the best treatment is to expose the fragments, refresh their edges, and wire them.

Fracture of the coronoid process is rare except as a complication of backward dislocation of the elbow. It may be produced by direct violence, as well as by muscular action. As the fracture is usually within a quarter of an inch of the tip, the fibres of insertion of the brachialis anticus tend to prevent displacement. The ordinary evidences of fracture are often absent, and the diagnosis is seldom completed without the aid of the X-rays. The treatment consists in flexing the elbow and supporting the forearm in a sling. In some cases associated with dislocation, however, the small fragment has been so far displaced as to become attached to the back of the condyles of the humerus (Annandale).

FRACTURES OF THE UPPER END OF THE RADIUS

Intra-capsular fracture of the **head of the radius** may result from direct violence, from a fall on the pronated hand, or from

forcible pronation or abduction—that is, deviation of the forearm to the radial side. It may accompany dislocation of the elbow or fracture of adjacent bones. The head may be completely separated, or may be split into two or more fragments. Up to the seventeenth year, the *epiphysis*, which is entirely intra-articular, may be separated.



FIG. 152.—Gooch Splint for Fracture of Olecranon. Note “carrying angle.”

The *clinical features* are localised pain, crepitus, interference with pronation and supination, while the elbow can be almost fully extended and flexed, and in some cases the fragment may be felt through the skin, although it usually continues to move with the shaft in pronation and supination.

Union generally takes place satisfactorily, but in some cases the fragments form new attachments resulting in impaired movement at the elbow, and necessitating operative interference.

Fracture of the **neck of the radius** between the capsule and the tubercle is rare.

Avulsion of the tubercle may occur from forcible contraction of the biceps, or, in children, from traction made on the forearm (A. L. Hall).

These injuries are treated with the elbow in the flexed position, and massage and movement are carried out as already described.



FIG. 153.—Fracture of Coronoid Process.

DISLOCATIONS OF THE ELBOW

Dislocations of the elbow-joint may involve one or both bones of the forearm, and may be complete or incomplete.

Dislocation of both bones backward is the most common of all dislocations of the elbow, and is the only dislocation in the body that is frequently met with in children. It usually results from a fall on the outstretched hand, causing hyperextension of the joint with abduction—that is, lateral deviation towards the radial side; but it may follow a direct blow on the back of the humerus, a fall on the elbow, or a twist of the forearm.

Morbid Anatomy.—All the ligaments of the elbow, except the orbicular, are torn or stretched. The radius and ulna pass backward, the coronoid process coming to rest opposite the olecranon fossa behind the humerus, and the head of the radius behind the external condyle. The condyles of the humerus bear their normal relations to one another. The olecranon process and triceps tendon form a marked prominence on the back of the elbow, the tip of the olecranon lying above and behind the condyles. The lower end of the humerus lies in the flexure of the joint with the biceps tendon tightly stretched over it. The coronoid process is often broken, or the tendon of the brachialis anticus torn. The median and ulnar nerves may be stretched or torn. Not infrequently the bones of the forearm are displaced towards the inner side as well as backward.

Occasionally, as a sequel to backward dislocation of the elbow, processes of bone develop in relation to the insertion of the brachialis anticus, and interfere with the movements of the joint. These out-growths are due to displacement of bone-forming elements, either at the time of the original injury, or as a result of forcible efforts at reduction. According to D. M. Greig, they do not develop in

the tendon of the brachialis anticus, but under it, and are not of the nature of myositis ossificans. In from four to six weeks after reduction of the dislocation, the mobility of the joint begins to be restricted, and a hard mass can be felt in the ante-cubital fossa, which with the X-rays is seen to be a bony out-growth springing from the quadrilateral space on the front of the elbow below the coronoid process (Fig. 156). This gradually increases in size and leads to fixation of the joint. In most cases the effects reach their maximum in about six months, and then reabsorption of the mass begins.



FIG. 154.—Backward Dislocation of Elbow, in a boy æt. 10, caused by a fall off a wall, landing on the elbow.

If the disability shows no sign of abatement within a year, or if the bony out-growth is producing pressure effects on the median nerve, it should be removed by operation.

It is important not to mistake this condition for the effects of a fracture which has complicated the dislocation and been overlooked at the time of the accident.

Clinical Features.—The elbow is held fixed at an angle of about 120° , pronated or midway between pronation and supination (Fig. 154). Any attempt at movement causes great pain, and is followed by an elastic rebound to the abnormal position. The antero-posterior diameter of the joint is increased, and the forearm, as measured from the external condyle to the tip of the styloid process of the radius, is shortened to the extent of about an inch. If examined before swelling ensues, the outlines of the articular surfaces may be recognised in their abnormal positions, but swelling usually comes on rapidly, and, by obscuring the bony landmarks, renders the diagnosis difficult.

This injury has to be diagnosed from supra-condylar fracture with backward displacement of the lower fragment and from separation of the lower humeral epiphysis. A general anæsthetic is often necessary to enable an accurate diagnosis to be made. When the deformity is once reduced, there is no tendency to its reproduction unless the coronoid process is also fractured. In a considerable number of cases—according to E. H. Bennett, in the majority—this dislocation is *incomplete*, the coronoid process resting at the level of the trochlea, and the backward projection of the olecranon being scarcely appreciable. The head of the radius, however, is unduly prominent. In such cases the lesion is liable to be overlooked, and therefore to go untreated, leading to permanent impairment of function of the joint.

Dislocation forward is much less common than the backward variety. It is produced by severe force acting from behind on the flexed elbow, the ulna being driven forward, tearing the ligaments of the joint and the muscles attached to the condyles. The olecranon process is frequently fractured at the same time (Fig. 158). When it remains intact, it may rest below the condyles (incomplete or first stage of dislocation), or may pass in front of them, especially if the triceps is ruptured (complete or second stage). The forearm is lengthened, the elbow slightly flexed, the posterior aspect of the joint flattened, and the condyles, in their abnormal relationship, can be palpated from behind.

Lateral Dislocations.—Dislocation towards the ulnar side—

inward—is always incomplete, some portion of the articular surface of the bones of the forearm remaining in contact with the condyles.



FIG. 155.—Radiogram of Complete Backward Dislocation of Elbow.

(Photograph by Dr. Dawson Turner.)

The radial or *outward* dislocation is also incomplete as a rule, although cases have been recorded in which complete separation had taken place.

Both forms of lateral dislocation are rare, the inward variety being that more frequently observed. Each form is often combined with other injuries in the region of the joint. 156

The most common cause of these dislocations is a fall on the outstretched hand, the forearm at the moment being strongly



FIG. 156.—Bony Out-growth in relation to insertion of Brachialis Anticus, following Backward Dislocation of Elbow.

(Mr. Robert Jones' case. Radiogram by Dr. D. Morgan.)

pronated. Forced abduction favours the inward displacement; adduction the outward. The limb is held flexed and pronated, and the facility with which the bony points can be palpated renders the diagnosis easy.

In a few cases *diverging dislocations* have been met with, the radius and ulna being separated from one another, the

orbicular ligament being torn and no longer holding them together.

Treatment of Dislocations of Elbow.—The chief obstacle to reduction in the *backward and lateral dislocations* is the spasmodic contraction of the muscles passing over the joint, and sometimes the hitching of the coronoid process against the edge of the olecranon fossa. In recent cases, to effect reduction the patient is seated on a chair, while the surgeon grasps the humerus and wrist, and places his knee in the bend of the elbow. The limb is first fully extended, or even hyper-extended, to relax the triceps and free the coronoid process. Traction is then made in opposite directions upon the forearm and upper arm, the surgeon's knee meanwhile making pressure, in a backward direction, upon the lower end of the humerus. The joint is next slowly flexed, and the bones slip into position, often with a distinct snap. If the patient be anæsthetised, these manipulations must be adapted to the recumbent position.

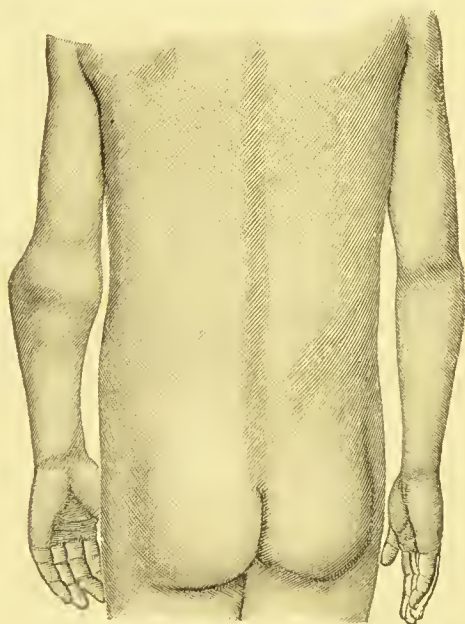


FIG. 157.—Backward and outward Dislocation of Bones of Forearm on Left Side, in a boy æt. 10.

When some days have elapsed before reduction is attempted, adhesions must be broken down by flexing, extending, and laterally moving the joint, under an anæsthetic, before the above manipulations are carried out. To avoid the risk of ossification occurring at the insertion of the brachialis anticus, which is apt to follow upon forcible manipulations, the dislocation may be reduced by open operation (D. M. Greig).

After reduction, the limb is flexed to rather less than a right angle and supported by a sling. Massage and movement are commenced at once.

Fracture of the coronoid process predisposes to recurrence of the dislocation; when this complication exists, therefore,

the limb should be fixed at an acute angle, and movements of full extension postponed for a fortnight. Massage and limited movements, however, may be carried out from the first.

If there is a fracture of the olecranon process, the treatment must be modified accordingly (p. 516).

Comminuted and compound injuries usually call for operative treatment, the fractured bones being wired after reduction of the dislocation, or the loose fragments removed.

The *forward dislocation* is reduced by fully flexing the elbow, and then pushing the bones of the forearm backward, while the humerus is pulled forward.

Old-standing Dislocations.—It is seldom possible to reduce by manipulation a dislocation of the elbow which has remained displaced for five or six weeks, especially when it has been complicated by a fracture. The joint surfaces become welded together by adhesions, and separated fragments often form attachments which completely lock the joint. Attempts to break these down are attended with considerable risk of re-fracturing the bone or of tearing the soft parts. In such cases it is best to expose the joint and to remove a sufficient amount of the lower end of the humerus to provide a movable and useful joint.

Dislocation of the ulna alone is a rare injury, and is usually associated with fracture of one or other of its processes or of the internal condyle.

Dislocation of the radius alone, on the other hand, is comparatively common, especially as a concomitant of fracture of the upper third of the shaft of the ulna (Fig. 159).

The injury may result from a blow on the back of the upper end of the radius, a fall on the outstretched hand, or, in children, from forcible traction on the forearm while in the pronated position. The displaced head usually passes *forward*, and rests on the anterior edge of the capitellum, thus preventing complete flexion and supination of the limb.

The limb is held partly flexed and pronated. The displaced head of the radius can be felt to rotate with the shaft in its abnormal position, and the articular facet on the head of the radius may also be felt; there is a depression posteriorly below the external condyle where the head should be. The radial side of the forearm is slightly shortened. The radial and posterior interosseous branches of the musculo-spiral nerve are liable to be pressed upon or torn by the displaced head of the radius, especially if the ulna is fractured, leading to disturbances in the area of their distribution.

In a few cases the displacement of the head has been *backward* or *outward*.

Treatment.—To effect reduction, the forearm should be alternately flexed and extended, while traction is made upon it from the wrist, and the head of the radius is pressed backward with the thumb in the fold of the elbow. When reduction is pre-



FIG. 158.—Forward Dislocation of Elbow, with Fracture of Olecranon.

(Mr. Robert Jones' case. Radiogram by Dr. D. Morgan.)

vented by the interposition of a portion of the torn ligaments between the bones, it is sometimes necessary to open the joint to ensure accurate adjustment. The joint is fixed in acute flexion to relax the biceps, to allow of union of the torn ligaments, and to prevent recurrence.

In old-standing cases, to obtain a useful joint, or to remove pressure from the branches of the musculo-spiral nerve, resection of the head of the radius may be necessary.

Sub-luxation of the head of the radius, or "dislocation by elongation," is a comparatively common injury in children between the ages of two and six. It almost invariably results from the child being lifted or dragged by the hand or forearm. The traction and torsion thus put upon the radius causes the front part of its head to pass out of the orbicular ligament, the edge of which slips between the bones.

The person holding the child may feel a click at the moment of displacement. The child complains of pain in the region of the elbow; the arm at once becomes useless, and is held flexed, midway between pronation and supination. All movements are painful, but especially movements in the direction of supination. The deformity is slight, but the head of the radius may be unduly prominent in front. From the way in

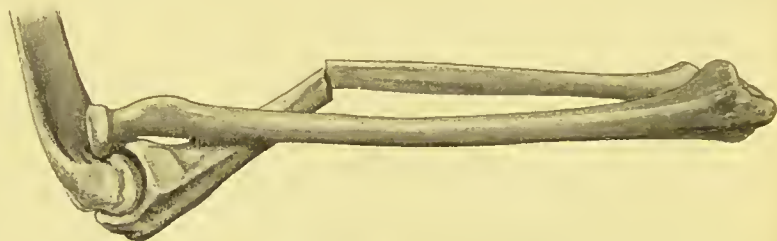


FIG. 159.—Forward Dislocation of Head of Radius, with Fracture of Shaft of Ulna.

which the injury is produced the wrist also is often swollen, and in some cases the patient is brought to the surgeon on account of the condition of the wrist, and attention is not directed to the elbow.

Treatment.—Reduction frequently takes place spontaneously or during examination, the function of the arm being at once completely restored. In other cases it is necessary, under anæsthesia, to manipulate the head of the bone into position. This is usually easily done by flexing the elbow, making slight traction on the forearm, and alternately pronating and supinating it. After reduction, a few days' massage is all that is necessary, the joint in the intervals being kept at rest in a sling.

Sprains of the elbow are comparatively common as a result of a fall on the hand or a twist of the forearm. The point of maximum tenderness is usually over the radio-humeral joint, the external lateral and orbicular ligaments being those most frequently damaged. Effusion takes place into the synovial cavity, and a soft, puffy swelling fills up the natural hollows

about the joint. The bony points about the elbow retain their normal relationship to one another—a feature which aids in determining the diagnosis between a sprain and a dislocation or fracture. In children it is often difficult to distinguish between a sprain and the partial separation of an epiphysis. Sprains of the elbow are treated on the same lines as similar lesions elsewhere—by massage and movement.

The condition known as *tennis elbow* is characterised by severe pain over the attachment of one or other of the muscles about the elbow, particularly the insertion of the pronator radii teres during the act of pronation, and is due to stretching or tearing of the fibres of that tendon, and of the adjacent inter-muscular septa. A similar injury—*sculler's sprain*—occurs in rowing men from feathering the oars. The treatment consists in massage and movement, care being taken to avoid the movements which produced the injury. In persistent cases, blistering or the use of hot-air baths may be useful.

FRACTURES OF THE FOREARM

The *shafts* of the bones of the forearm may be broken separately, but it is much more common to find both broken together.

Fracture of both bones may result from a direct blow, from a fall on the hand, or from their being bent over a fixed object. The line of fracture is usually transverse, both bones giving way about the same level. The common situation is near the middle of the shafts. In children, greenstick fracture of both bones is a frequent result of a fall on the hand—this indeed being one of the commonest examples of greenstick fracture met with (Fig. 160).

The *displacement* varies widely, depending partly upon the force causing the fracture, partly on the level at which the bones break, and on the muscles which act on the respective fragments. It is common to find an angular displacement of both bones to the radial or to the ulnar side. In other cases the four broken ends impinge upon the interosseous space, and may become united to one another, preventing the movements of pronation and supination. There may be shortening from over-riding of fragments.

When the radius is broken above the insertion of the pronator radii teres, its upper fragment may be supinated by the biceps and supinator brevis, while the lower fragment remains in the usual semi-prone position. If union takes place in this position, the power of complete supination is permanently lost.

The usual *symptoms* of fracture are present, and there is seldom any difficulty in diagnosis.

The *prognosis* must be guarded, especially with regard to the preservation of pronation and supination. These movements may be interfered with if union takes place in a bad position with angular or rotatory deformity of one or both bones, or if callus is formed in excess and causes locking of the bones. In some cases the callus fuses the two bones across the interosseous space, and pronation and supination are rendered impossible.

Persistent angular deformity of the forearm is also liable to ensue, either from failure to correct the displacement primarily, or from subsequent bending due to ill-applied splints or slings. Want of union, or the formation of a false joint in one or both bones, is sometimes met with, particularly in children, and, like



FIG. 160.—Greenstick Fracture of both Bones of the Forearm.

the corresponding fracture of the leg, is liable to prove very intractable (Fig. 161).

A considerable number of cases of gangrene of the limb after simple fracture of the forearm are on record. This is sometimes attributable to damage inflicted upon the blood-vessels by the fractured bones, or to the force that caused the fracture, but is oftener due to a roller bandage applied underneath the splints strangulating the limb, to injudiciously applied pads, or to too tight bandaging over the splints. Volkmann's ischæmic contracture occasionally develops after fractures of the forearm.

In uncomplicated cases, union takes place in from three to four weeks.

Treatment.—To ensure accurate reduction and coaptation, a general anæsthetic is usually necessary. In the greenstick variety the bones must be completely straightened, the fracture being rendered complete, if necessary, for this purpose.

To retain the bones in position, anterior and posterior splints are then applied. These are made to overlap the forearm by about half an inch on each side, to avoid compressing the forearm laterally, and so making the fractured ends encroach upon the interosseous space. The dorsal splint is usually made to extend from the olecranon to the knuckles, and the palmar one from the bend of the elbow to the flexure in the middle of the palm, a piece being cut out to avoid pressure on the ball of the thumb (Fig. 162). The splints are applied with the elbow

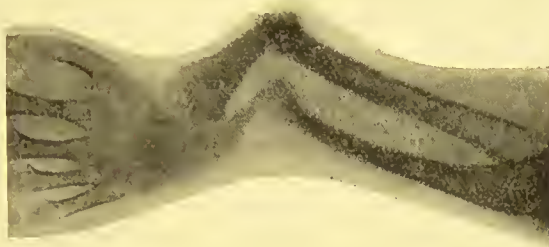


FIG. 161.—Un-united Fracture of both Bones of Forearm in a child. Subsequently cured by operation.

flexed to a right angle, and, except when the radius is broken above the level of the insertion of the pronator radii teres, with the forearm midway between pronation and supination. The limb is placed in a sling, so adjusted that it supports equally the hand and elbow in order to avoid angular deformity, and the upper arm fixed by a body bandage. The use of special interosseous pads is to be avoided, as they are liable to cause gangrene of the skin.

When the fracture of the radius is above the insertion of the pronator radii teres, the forearm should be placed in the position of complete supination, with the elbow flexed to an acute angle, and retained in this position by a moulded posterior splint, and the arm fixed to the side by a body bandage. Great care is necessary in the adjustment of the apparatus to prevent pronation.

Massage and movement should be carried out from the first. It is usually necessary to continue wearing the splints for about three weeks.

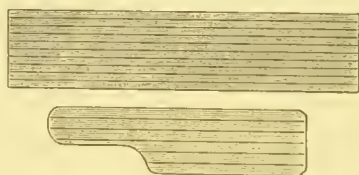


FIG. 162.—Gooch Splints for Fracture of both Bones of Forearm. (These are applied with the wooden side towards the skin.)

In cases of *mal-union*, especially when the bones are ankylosed to one another across the interosseous space, operation may be necessary, but it is neither easy in its performance nor always satisfactory in its results. The seat of fracture should be exposed by one or more incisions so placed as to enable the muscles to be separated and to give access to the callus. When the limb is straight, it is only necessary to gouge away the exuberant callus that interferes with rotatory movements; but when there is an angular deformity (Fig. 164) the bones must, in addition, be divided and re-set, and, if necessary, wired in good position. In comparatively recent cases it is sometimes possible, without operation, to re-fracture the bones and to set them anew.

Un-united fracture of the bones of the forearm (Fig. 161) is treated on the usual lines.

Fracture of the shaft of the radius alone may be due to a

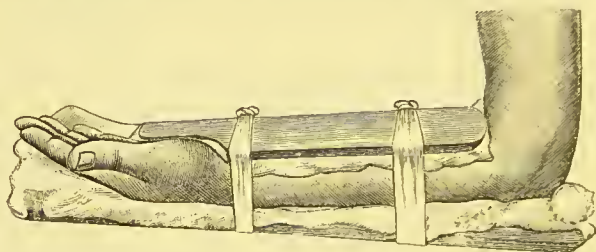


FIG. 163.—To illustrate Splints for Fracture of Forearm.

direct blow; to indirect violence, such as a fall on the hand; or to forcible pronation against resistance, as in wringing clothes. It is rare in comparison with fracture of both bones. When broken above the insertion of the pronator radii teres, the upper fragment is flexed and supinated by the biceps and supinator brevis, while the lower fragment remains semi-prone, and is drawn towards the ulna by the pronator quadratus.

When the fracture is below the pronator radii teres, the displacement depends upon the direction of the force and the obliquity of the fracture. In fractures of the lower third of the shaft, the hand may be flexed toward the radial side, and the styloid lies at a higher level, as in a Colles' fracture.

In addition to the ordinary signs of fracture, there is partial or complete loss of pronation and supination. The head of the radius as a rule does not move with the lower part

of the shaft, but may do so if the fracture is incomplete or impacted.

Fracture of the shaft of the ulna alone is also comparatively rare. It is almost always due to a direct blow sustained while protecting the head from a stroke, or to a fall on the ulnar edge of the forearm, as in going up a stair.

The upper third is most frequently broken, and this injury is often associated with dislocation of the head of the radius (Fig. 159), or some other injury implicating the elbow-joint. On account of the superficial position of the bone, this fracture is frequently compound.

The displacement depends on the direction of the force, the fragments being usually driven towards the interosseous space. There is seldom marked deformity unless the head of the radius is dislocated at the same time. The diagnosis is, as a rule, easy.

The *treatment* is the same as for fracture of both bones, but the splints may be dispensed with at the end of a fortnight.



FIG. 164.—Badly united Fracture of both Bones of Forearm. Boy æt. 11. Probably an unreduced greenstick fracture.

CHAPTER XXIV

INJURIES IN THE REGION OF THE WRIST AND HAND

Surgical Anatomy—FRACTURES OF LOWER END OF RADIUS: *Colles' fracture*; *Chauffeur's fracture*; *Smith's fracture*; *Longitudinal fracture*; *Separation of epiphysis*—FRACTURES OF LOWER END OF ULNA: *Shaft*; *Styloid process*; *Separation of epiphysis*—FRACTURES OF CARPAL BONES—DISLOCATIONS: *Inferior radio-ulnar joint*; *Radio-carpal joint*; *Carpal bones*; *Carpometacarpal joint*—SPRAINS.

INJURIES IN THE REGION OF THE WRIST

THESE include fractures of the lower ends of the bones of the forearm, or separation of their epiphyses; sprains and dislocations of the inferior radio-ulnar, and of the radio-carpal articulations; and fractures and dislocations of the carpus.

Surgical Anatomy.—The most important landmarks in the region of the wrist are the styloid processes of the radius and ulna. The tip of the radial styloid is palpable in the "anatomical snuff-box" between the tendons of the extensor brevis and extensor longus pollicis, and it lies about half an inch lower than the ulnar styloid. The ulnar styloid is best recognised on making deep pressure a little below and in front of the head of the ulna, which forms the rounded subcutaneous prominence seen on the back of the wrist when the hand is pronated.

The tubercle of the scaphoid and the trapezium can be felt between the radial styloid and the ball of the thumb, a little below the radial styloid; and the pisiform and hook of the unciform are palpable, slightly below and in front of the ulnar styloid.

In examining an injured wrist, the different bony points should be located, and their relative positions to one another and to the adjacent joints noted; and the shape, position, and relations of any unnatural projection or depression observed. The power and range of movement—active and passive—at the various joints should also be tested.

FRACTURES OF THE LOWER END OF THE RADIUS

Colles' Fracture.—This injury, which was first described by Colles of Dublin in 1814, is one of the commonest fractures

in the body, and is especially frequent in women beyond middle age. It is almost invariably the result of a fall on the palm of the hand, in the three-quarters pronated position (Fullerton), the force being received on the ball of the thumb, and transmitted through the carpus to the lower end of the radius. "If at the moment of impact the angle between the axis of the forearm and ground is less than 60° , the line representing the direction of the force passes upwards in front of the axis of the forearm; the whole shock is therefore borne by the lower end of the radius, which is broken off, and the force being continued, the lower fragment is driven backwards" (John Chiene).

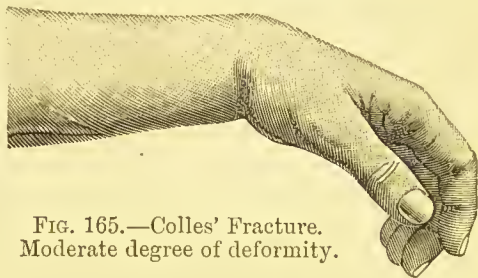


FIG. 165.—Colles' Fracture.
Moderate degree of deformity.

The fracture takes place through the cancellated extremity of the bone, within a half to three-quarters of an inch of its articular surface (Fig. 167). It is usually transverse, but may be slightly oblique, from above downwards and from without inwards. In a considerable proportion of cases it is impacted, and not infrequently the lower fragment is comminuted, the fracture extending into the radio-carpal joint.



FIG. 166.—Colles' Fracture, in a man æt. 30,
from a fall on the palm. "Inverted-spoon"
deformity well marked.

When impaction takes place, it is usually reciprocal, the dorsal edge of the upper fragment piercing the lower fragment, and the palmar edge of the lower fragment piercing the upper. The mechanism producing comminution of the lower fragment is practically constant, the upper fragment being forced as a wedge into the lower, taking effect first and chiefly on the side of the fragment next the ulna (E. H. Bennett). The periosteum is usually torn and stripped from the palmar aspect of the fragments, while it remains intact on the dorsum.

In the majority of cases the styloid process of the ulna is torn off by traction exerted through the internal lateral ligament.

The resulting *displacement* is of a threefold character: (1) the lower fragment is displaced backwards; (2) its carpal surface is rotated backwards on a transverse diameter of the forearm; while (3) the whole fragment is rotated upward through the arc of a circle, the centre of which is situated at the ulnar attachment of the triangular ligament, the radius of the circle being a line from the ulnar attachment of the triangular ligament to the tip of the styloid process of the radius: stated more simply, the radial styloid is tilted so that it comes to lie at a higher level than normal (John Chiené).

Clinical Features.—In a typical case there is a marked prominence on the back of the wrist, caused by the displaced lower fragment, with a depression just above it (Fig. 166); and the wrist is broadened from side to side. The natural hollow on the palmar aspect of the radius is filled up by the projection of the upper fragment. The carpus is carried to the radial side by the upward rotation of the lower fragment, and the radial styloid is raised so that it lies as high, or even higher, than that of the ulna. The lower end of the ulna is rendered unduly prominent by the flexion of the hand to the radial side. The fingers are partially flexed and slightly deviated towards the ulnar side; and the patient supports the injured wrist in the palm of the opposite hand, and avoids movement of the part.

The general outline of the wrist and hand has been compared not inaptly to that of "an inverted spoon." Pronation and supination are lost, the joint is swollen, and there is tenderness on pressure, especially over the line of fracture. Tenderness over the position of the ulnar styloid may indicate fracture of that process, although it is sometimes present without fracture, and has been absent in cases in which a fracture was demonstrated by the Röntgen rays (Cathcart). No attempt should be made to elicit crepitus in a suspected case of Colles' fracture, as the manipulations are extremely painful, and are liable to increase the displacement. As a matter of fact, it may be wanting in any form of this injury. Its absence, further, is not to be accepted as proving impaction. In some cases the damage is confined to the articular surface, and there is no displacement or deformity, and unless the X-rays are used the condition is mistaken for a sprain. Occasionally the median nerve is bruised or torn, causing motor and sensory disturbances in its area of distribution.

Treatment.—It cannot be too strongly insisted upon that

success in the treatment of Colles' fracture with typical and marked displacement depends chiefly upon complete and accurate reduction, and to enable this to be effected a general anæsthetic is of great assistance, especially when impaction exists. The surgeon grasps the patient's hand, as if shaking hands with him, and, resting the palmar surface of the wrist on his bent knee, makes traction through the hand, and counter-extension through the forearm, with lateral movements, if necessary, to undo impaction. When the fragments are freed from one another, the wrist is flexed, and the hand carried to the ulnar side, while the fragments are moulded into position by the thumb of the surgeon's disengaged hand. When reduction is complete, the deformity almost entirely disappears, and the two styloid processes regain their normal positions relative to one another.

As there is no tendency to re-displacement, no retentive apparatus is required, but, as it adds to the patient's sense of security, a firm flannel bandage, or a poroplastic wristlet may be applied. In severe cases, however, anterior and posterior splints, similar to those used for fracture of both bones of the forearm, or a dorsal splint padded so as to flex the wrist to an angle of 45° but somewhat narrower, may be employed (P. Heron Watson). The hand and forearm are in any case supported in a sling.

To avoid the stiffness which often follows this fracture, the massage and gentle movement of the wrist and fingers should be carried out from the first, the range of movement being gradually increased until the function of the joints is perfectly restored. If splints are used, they should be discarded in a week, and the patient is then encouraged to use the wrist freely.

The various special splints recommended for the treatment of Colles' fracture, such as Carr's, Gordon's, the "pistol splint," and many others, are all designed to correct the deformity as well as to control the fragments. It has already been pointed out that if reduction is complete there is no deformity to correct, and if it is not complete the deformity cannot be corrected by any form of splint.

Unreduced Colles' Fracture.—When union has been allowed to take place without gross displacement having been reduced, an unsightly deformity results. In young subjects whose occupation is likely to be interfered with, and in women for æsthetic reasons, the fracture is reproduced by a Jones' wrench, and set in the normal position. Operative treatment may be

called for, also, on account of involvement of the median nerve in callus.

Chauffeur's Fracture.—A fracture of the lower end of the radius frequently occurs from the recoil of the crank, "by back-firing," in starting the engine of a motor-car. The injury may be produced either by direct violence, the handle as it recoils striking the forearm, or by indirect violence, from forcible hyper-extension of the hand while grasping the handle. The fracture may pass transversely through the epiphysial portion of the radius, as in Colles' fracture, or may extend into the lower third of the shaft. It is treated on the same lines as Colles' fracture.

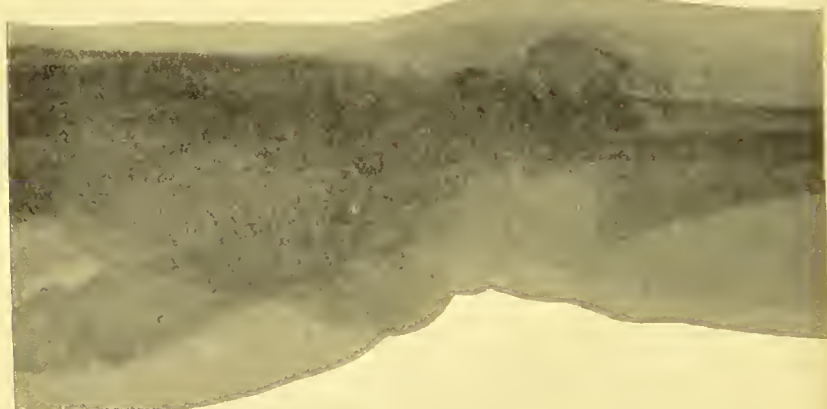


FIG. 167.—Radiogram of Colles' Fracture in woman æt. 50. Lateral view.

(Mr. J. W. Struthers' case. Radiogram by Dr. F. K. Kerr.)

A fracture of the lower end of the radius *with forward displacement of the carpal fragment*, was first described by R. W. Smith of Dublin (*Colles' fracture reversed*, or **Smith's fracture**) (Fig. 169). It is nearly always due to forcible flexion, as from a fall on the back of the hand. Like Colles' fracture, it may be transverse or slightly oblique, impacted, or comminuted. The deformity is characterised by an elevation on the dorsum running obliquely upwards from the ulnar to the radial side of the wrist, and caused by the head of the ulna, which remains in position, and the lower end of the upper fragment. Below this, over the position of the lower radial fragment, is a gradual slope downwards on to the dorsum of the hand. Anteriorly there is a prominence in the flexure

of the wrist, and the lower fragment may be felt under the flexor tendons. The hand deviates to the radial side, and thereby still further increases the prominence caused by the lower end of the ulna. The radial styloid is displaced forward, upward, and to the radial side, and the ulnar styloid may be torn off. Crepitus can seldom be elicited.

When the deformity is not well marked, this injury may be mistaken for forward dislocation of the wrist, for fracture of both bones low down, or for sprain of the joint.

The *treatment* is carried out on the same lines as in Colles' fracture.



FIG. 168.—Manus Valga following separation of lower radial epiphysis in childhood.

(Mr. H. Wade's case.)

Longitudinal fractures of the lower end of the radius opening into the joint usually result from the hand being crushed by a heavy weight or in machinery. They are often compound and comminuted.

Separation of the lower epiphysis of the radius, which is on the same level as that of the ulna (Fig. 171) and lies above the level of the synovial membrane of the wrist-joint, is comparatively common between the ages of seven and eighteen, especially in boys, and is caused by the same forms of violence as produce Colles' fracture.

Although clinically the appearances in these two injuries bear a general resemblance to one another, separation of the epiphysis may usually be identified by the directly transverse



FIG. 169.—Radiogram of Smith's Fracture.
(Sir George T. Beaton's case.)

line of the dorsal and palmar projections, the folding of the skin observed in the palmar depression, the absence of abduction of the hand, and the ease with which muffled crepitus can be elicited (E. H. Bennett). The deformity is readily reduced, and the fragments are easily retained in position.

This injury is often complicated with fracture of the shaft or styloid process of the ulna, or with dislocation of the radio-ulnar joint, and it is not infrequently compound. Retardation of growth in the radius seldom occurs; when it does, it results in a valgus condition of the hand, calling for resection of the lower end of the ulna.

The *treatment* is the same as for Colles' fracture.

Fractures of the Lower End of the Ulna.—The lower end of the *shaft* of the ulna is seldom fractured alone. The *styloid*



FIG. 170.—Smith's Fracture of Radius, united in deformed attitude.

(Museum of Royal College of Surgeons, Edinburgh.)

process, as has already been pointed out, is frequently broken in association with Colles' and other fractures of the lower end of the radius.

Separation of the *lower epiphysis* of the ulna sometimes occurs, and in rare cases results in arrest of the growth of the bone, leading to a varus condition of the hand and bending of the radius. Sometimes the separated epiphysis fails to unite, and although this gives rise to no disability, it is liable to lead to errors in the interpretation of skiagrams.

The *treatment* is similar to that for the corresponding injuries of the radius.

Simultaneous separation of the *epiphyses of both radius and ulna* sometimes occurs, and, as a result of severe violence, may be compound, the lower ends of the diaphyses projecting through the skin on the dorsum.

Fractures of Carpal Bones.—The use of the Röntgen rays has shown that fracture of individual carpal bones is commoner than has hitherto been supposed, and that many cases

formerly looked upon as severe sprains are examples of this injury.

The *scaphoid* is broken more frequently than any of the others, usually by direct violence or by forced dorsiflexion from a fall on the extended hand. The clinical features are: localised swelling on the radial side of the wrist, marked tenderness in the anatomical snuff-box when the hand is moved laterally, especially in the direction of adduction, and, sometimes, crepitus. In many cases, however, the symptoms are so obscure that an accurate diagnosis can only be made by the use of the X-rays. The fracture is often compound and associated with other injuries, particularly forward dislocation of the semilunar bone and dorsal dislocation of the os magnum.

The *treatment* of simple fractures consists in massage and movement from the first. The wrist and carpal joints may be supported by a palmar splint, the metacarpals being slightly hyper-extended. Codman and Chase recommend excision of the proximal half of the fractured bone, through a posterior incision to the outer side of the extensor communis digitorum. When the fracture is compound, the loose fragments should be removed.

DISLOCATIONS IN THE REGION OF THE WRIST

Dislocation may occur at the inferior radio-ulnar, the radio-carpal, mid-carpal, inter-carpal or carpo-metacarpal joints, but the strong ligaments of these articulations, the comparatively free movement at the various joints, and the relative weakness of the lower end of the radius whereby it is so frequently fractured, render dislocation a rare form of injury.

Dislocation of the **inferior radio-ulnar** articulation is seldom met with except as a complication of fracture of the lower end of the radius, or in association with sub-luxation of the head of the radius. The head of the ulna usually passes backward, less frequently forward, and but rarely towards the ulnar side.

In children, the commonest cause is lifting the child by the hand, and the displacement, as a rule, is only partial.

In adults, it may result from forcible efforts at pronation or supination, as in wringing clothes, or from direct violence, the separation being frequently complete, and sometimes compound.

The head of the ulna forms a prominence on the dorsal or palmar aspect of the wrist, according to the direction in which it passes, and there is an undue depression on the opposite aspect of the joint. The hand is generally pronated, the rotatory

movements at the wrist being restricted and painful, while flexion and extension are comparatively free. When uncomplicated, the dislocation is easily recognised, but when complicated with fracture it is apt to be overlooked.

Reduction is readily effected by making direct pressure on the displaced bone and manipulating the joint, especially in the direction of supination.

Dislocation at the **radio-carpal** articulation, usually spoken of as *dislocation of the wrist*, is that most commonly met with in this region. It is attended by great tearing of the ligaments and displacement of tendons, is frequently compound, and may be complicated by fracture of the lower ends of the bones of the forearm. The carpus may be displaced backward or forward, and the displacement is usually complete. It is not uncommon for that articular edge of the radius towards which the carpus passes to be chipped off.

In most cases the carpus is dislocated *backward*, and the injury results from a severe form of violence, such as a fall from a height on the palm while the hand is dorsiflexed and abducted. The clinical appearances closely simulate those of Colles' fracture, or of separation of the lower radial epiphysis, but the unnatural projections, both in front and behind, are lower down, and end more abruptly (Fig. 172). The hand is more flexed, and the palm is shortened. The styloid processes retain their normal relations to one another, but that of the radius is nearer to the thumb than it should be, and the carpal bones are found to lie on a plane posterior to the styloids. The forearm is not shortened. Unless the swelling is great, the articular surfaces may be recognised on palpation.

Dislocation of the carpus *forward* may result from any form of forced flexion, such as a fall on the back of the hand, or from direct violence. The displaced carpus forms a marked

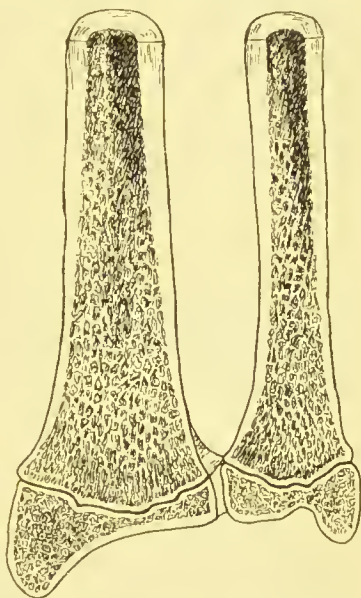


FIG. 171.—Section of lower end of Radius and Ulna to show line of Epiphyses.

(After Poland.)

projection on the palmar aspect of the wrist, and there is a corresponding depression on the dorsum. The attitude of the hand and fingers varies, but is usually one of flexion. In other respects this dislocation agrees with the dorsal variety.

In both varieties reduction is readily effected by making traction on the hand and pushing the carpus into position. A moulded poroplastic splint, which keeps the hand slightly dorsiflexed, adds to the comfort of the patient, but this should be removed daily to admit of movement and massage being employed.

Dislocation of Carpal Bones.—The two rows of carpal bones may be separated from one another, or any one of the individual bones may be displaced. These injuries are rare, and result from severe forms of violence, usually from a fall on the extended hand. Pain, deformity, and loss of function are the ordinary symptoms. The treatment consists in making

direct pressure over the displaced bones, while traction is made on the hand, which is alternately flexed and extended.

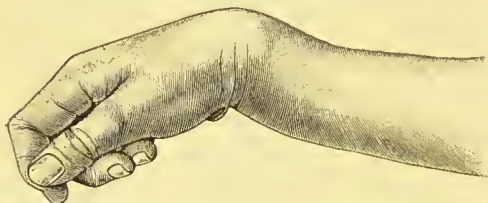


FIG. 172.—Backward Dislocation of Wrist at Radio-Carpal Articulation, in a man æt. 24, from a fall.

Of these injuries that most frequently observed is displacement of the *head of the os magnum* from the sca-

phoid and semilunar bones. Frequently these bones are fractured, and fragments accompany the displaced *os magnum*. In full palmar flexion of the wrist the displaced head of the *os magnum* forms a prominence on the dorsum opposite the base of the third metacarpal, which temporarily disappears when the hand is dorsiflexed. There is an increase in the antero-posterior diameter of the wrist, situated on a lower level than that which accompanies fracture of the lower end of the radius; flexion and extension of the wrist are limited; and in some cases there are symptoms referable to pressure on the median nerve. By keeping the hand in the dorsiflexed position for a week or ten days, the bone may become fixed in its place and the function of the wrist be restored, but it is often necessary to excise the bone.

The *semilunar* may be displaced forward by forcible dorsiflexion of the hand, and forms a projection beneath the flexor tendons; there is usually loss of sensibility in the distribution

of the ulnar nerve in the hand. The most satisfactory treatment is removal of the bone.

In a few cases the *scaphoid* has been displaced, and subsequently replaced by operation. Separation of any of the other bones is extremely rare.

Carpometacarpal Dislocations.—Any or all of the metacarpal bones may be separated from the carpus by forced movements of flexion or extension. The commonest displacement is backward. The thumb seems to suffer oftener than the other digits. These injuries, however, are so rare, and the deformity is so characteristic, that a detailed description is unnecessary.

There is good reason to believe that the injury commonly described as “incomplete dislocation,” or “sub-luxation of the metacarpal of the thumb backward,” is really a fracture of the base of the bone—an injury now known as Bennett’s fracture (p. 546).

Sprain of the wrist is a common injury, and may result from a fall on the hand, a twist of the wrist, or from the back-firing of a motor-erank dorsiflexing the hand. The marked swelling which rapidly ensues may render it difficult to distinguish a sprain from the more severe injuries that are liable to result from similar causes—Colles’ fracture, separation of the lower radial epiphysis, dislocation of the wrist, and fractures and dislocations of the carpal bones.

In a sprain the normal relations of the styloid processes and other bony points about the wrist are unaltered, and there is no radial deviation of the hand, as in Colles’ fracture. The most marked swelling is over the line of the articulation on the anterior and posterior aspects of the joint. There is usually some effusion into the sheaths of the tendons passing over the joint, and in some cases on moving the fingers a peculiar creaking, which may simulate crepitus, can be elicited. There is marked tenderness on making pressure over the line of the joint, as well as over one or other of the lateral ligaments, depending upon which ligament has been outstretched or torn. Movements that tend to put the damaged ligaments on the stretch also cause pain. It has to be borne in mind, however, that in many cases of Colles’ fracture there is extreme tenderness on pressing over the ulnar styloid and external lateral ligament, as these structures are frequently injured as well as the radius, but the point of maximum pain and tenderness is over the seat of fracture of the radius. In all doubtful cases the X-rays should be employed to establish the diagnosis.

The *treatment* consists in the immediate employment of massage and movement, supplemented by alternate hot and cold douches, on the same lines as in other sprains.

INJURIES OF THE FINGERS

Fractures.—*Fractures of the metacarpals of the four inner fingers* are comparatively common. When they result from direct violence, such as a crush between two heavy objects, they are often multiple and compound. Indirect violence, acting in the long axis of the bone and increasing its natural curve, such as a blow on the knuckle in striking with the closed fist, usually produces an oblique fracture about the middle of the shaft, the proximal end of the distal fragment projecting towards the dorsum of the hand. Apart from this there is little deformity, as

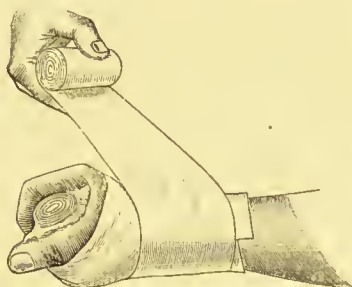


FIG. 173.—Treatment of Fracture of Metacarpals by Pad in the Palm and "Closed-fist" Bandage.

the adjacent metacarpals act as natural splints and tend to retain the fragments in position. A sudden sharp pain may be elicited at the seat of fracture on making pressure in the long axis of the finger; and unnatural mobility and crepitus may usually be detected.

These fractures are readily recognised by the X-rays. Firm union usually results in three weeks.

The shaft of the *metacarpal of the thumb* is frequently broken by a blow with the closed fist. The fracture is usually transverse, and situated near the

proximal end of the shaft; frequently it is comminuted, and in some instances there is a longitudinal split.

Treatment.—When the fracture is transverse, and especially when it implicates the middle or ring fingers, the most con-

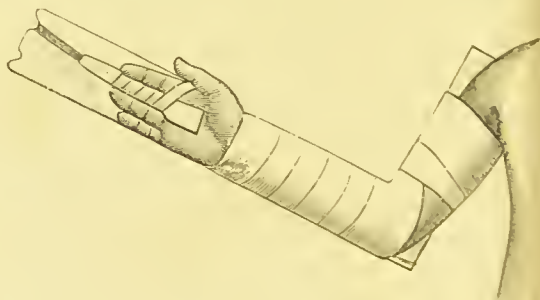


FIG. 174.—Extension applied for Oblique Fracture of Metacarpal.

venient method is to make the patient grasp a firm pad, such as a roller bandage covered with a layer of wool, and to fix the closed fist by a figure-of-eight bandage (Fig. 173). In this way the adjoining metacarpals are utilised as lateral splints. To



FIG. 175.—Radiogram of Bennett's Fracture of Base of Metacarpal of Right Thumb.

obtain a good functional result, active and passive movements must be carried out from the first, and the bandage may be removed at the end of a week or ten days.

In oblique fractures with a tendency to over-riding of the fragments, especially in the case of the index and little fingers,

it is sometimes necessary to apply extension to the distal segment of the digit, by means of adhesive plaster, to which elastic tubing is attached and fixed to the end of a rectangular splint reaching well beyond the finger-tips (Chiene) (Fig. 174). This should be worn for a week or ten days.



FIG. 176. — Splint for Fracture of Base of Metacarpal of Thumb.

Bennett's Fracture of the Base of the first Metacarpal Bone. — Bennett of Dublin described an injury of the thumb which, although comparatively common, is often mistaken for a sub-luxation back-

ward of the carpo-metacarpal joint, or a simple "stave of the thumb." It consists in an "oblique fracture through the base of the bone, detaching the greater part of the articular facet with that piece of the bone supporting it which projects into the palm" (Fig. 175). We have frequently observed the fracture extend for a considerable distance along the palmar aspect of the shaft.

It usually results from severe force applied directly to the point of the thumb, driving the metacarpal against the trapezium, and chipping off the palmar part of the articular surface, but may result from a blow with the closed fist. The

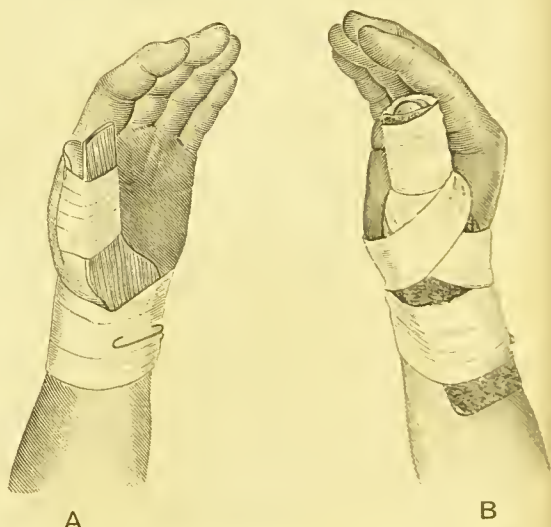


FIG. 177.—A. Splint applied as used by Bennett. B. Poroplastic Moulded Splint for Bennett's Fracture.

rest of the metacarpal slips backward, forming a prominence on the dorsal aspect of the joint. The pain and swelling in the region of the fracture often prevent crepitus being elicited, and as the deformity is not at once evident, the nature of the injury is liable to be overlooked. The fracture is recognised by the use of the X-rays. It may occur in either hand, but on account of the greater exposure of the right hand to injury it is commoner

on that side. The importance of making a correct diagnosis lies in the fact that unless properly treated this injury may result in prolonged impairment of function, full abduction and fine movements requiring close apposition of the thumb being specially interfered with.

The *treatment* consists in reducing the fracture by extension, and applying an accurately fitting pad over the extremity of the displaced bone, maintained in position by a light angular splint (Fig. 176). This splint is first fixed to the extended and abducted thumb, and while extension is made by pushing it downwards the upper end is fixed to the wrist (Fig. 177, A). The apparatus is worn for three weeks, being carefully readjusted from time to time to maintain the extension. A moulded poroplastic splint applied on the same principle may be employed, and is more comfortable (Fig. 177, B). Recent experience has shown that excellent results are obtained by massage and movement from the first and the support merely of a figure-of-eight bandage (Pirie Watson).

Fractures of phalanges usually result from direct violence, and, on account of the superficial position of the bones, are often compound, and attended with much bruising of soft parts. Force applied to the distal end of the finger also may fracture a phalanx. The proximal phalanges are broken oftener than the others. The deformity is usually angular, with the apex towards the palm, and if union takes place in this position, the power of grasping is interfered with. Unnatural mobility and crepitus can usually be recognised, but, on account of the swelling and tenderness, diagnosis is sometimes very difficult. Firm union takes place in two or three weeks. In oblique and comminuted fractures, union may take place with overlapping, producing a deformity which is sometimes troublesome by preventing the wearing of a glove or of rings. In compound fractures, non-union sometimes occurs, and causes persistent disability. In doubtful cases radioscopy renders valuable aid, as the parts are readily seen with the screen.

Treatment.—Early movement and massage are all-important. The contiguous fingers may be utilised as lateral splints, while a long palmar splint projecting beyond the fingers is employed to control the wrist-joint. In oblique and comminuted fractures it may be necessary to anaesthetise the patient to effect reduction. When it is particularly desirable to avoid deformity, an open operation may be advisable.

Dislocations.—*Dislocations of the metacarpo-phalangeal joint of the thumb.*—The commonest dislocation at this joint

is a *backward* displacement of the proximal phalanx, which may be complete or incomplete. Its special clinical importance lies in the fact that much difficulty is often experienced in effecting reduction.

This dislocation is usually produced by extreme dorsiflexion of the thumb, whereby the palmar or glenoid and the lateral ligaments are torn from their metacarpal attachments, the phalanx carrying with it the glenoid ligament and sesamoid bones. The head of the metacarpal passes forward

between the two heads of the flexor brevis pollicis, and the tendon of the long flexor slips to the ulnar side. The phalanx passes on to the dorsum of the metacarpal, where it is held erect by the tension of the abductor and adductor muscles.

The attitude of the thumb is characteristic (Fig. 178). The metacarpal is adducted, its head forming a marked prominence on the front of the thenar eminence, and the phalanges are displaced backwards, the proximal being dorsiflexed and the distal flexed towards the palm.



FIG. 178. — Backward Dislocation of Metacarpophalangeal Joint of Thumb.

Many explanations of the difficulty so often experienced in reducing this variety of dislocation have been offered, but the consensus of opinion now seems to be that it is due to the

interposition of the glenoid ligament and the sesamoid bones between the phalanx and the metacarpal, and that this is most frequently the result of ill-advised efforts at reduction. In some cases the tension of the long flexor tendon may be a factor in preventing reduction, but the "button-holing" by the short flexor is probably of no importance.

Reduction is to be effected by flexing and adducting the metacarpal while the phalanx is hyper-extended and pushed down towards the joint and levered over the head of the metacarpal.

When this manipulation fails, the glenoid ligament should be divided longitudinally through a puncture made with a tenotomy knife on the dorsal aspect of the joint, so as to separate the sesamoid bones and permit the passage of the head between them (Fig. 180). An open operation is seldom necessary.

Dislocation *forward* is rare. It results from forced flexion of the thumb with abduction, tearing the posterior and internal

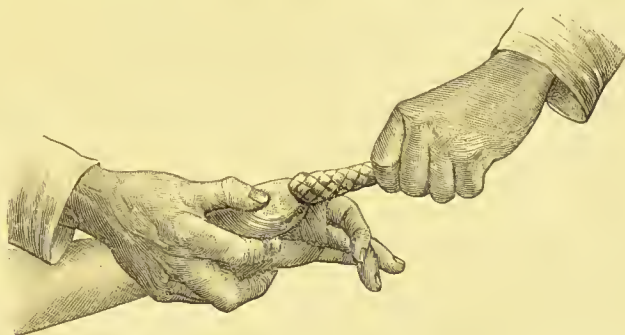


FIG. 179.—Reduction of Dislocation of Thumb with aid of "Indian Puzzle."

lateral ligaments. The deformity is characteristic: the rounded head of the metacarpal projecting behind the level of the joint,



FIG. 180.—To illustrate Method of dividing the Glenoid Ligament by Subcutaneous Operation.

while the base of the phalanx forms a prominence among the muscles of the thenar eminence.

Reduction is easily effected by making traction on the

phalanges and carrying out movements of flexion and extension. The deformity, however, is liable to be reproduced unless a retentive apparatus is securely applied.

Lateral dislocations of the thumb are very rare.

Dislocation of the *metacarpo-phalangeal joint of the fingers* may be backward or forward. They are less common than those of the thumb, but present the same general characters. In the backward variety the same difficulty in reduction as is met with in the corresponding dislocation of the thumb sometimes occurs, and is to be dealt with on the same principles.

Inter-phalangeal Dislocations.—The middle and the ungual phalanges may be displaced backwards, forwards, or laterally. The clinical features are characteristic, and the diagnosis, as well as reduction, is easy. These dislocations are frequently the result of machinery accidents, and being compound and difficult to render aseptic, often necessitate amputation.

Persistent flexion of the terminal phalanx of the thumb or fingers (*drop or mallet finger*) may result from violence applied to the end of the digit when in the extended position—as, for example, in attempting to catch a cricket-ball. The terminal phalanx is flexed towards the palm, and the patient is unable to extend it voluntarily.

CHAPTER XXV

INJURIES IN THE REGION OF THE PELVIS, HIP-JOINT, AND THIGH

FRACTURES OF PELVIS: *Varieties*—INJURIES IN REGION OF HIP:
Surgical anatomy; Fracture of head of femur; Fractures of neck of femur; Fracture below lesser trochanter—DISLOCATIONS OF HIP:
Varieties—Sprains—Contusions—FRACTURES OF SHAFT OF FEMUR.

FRACTURE OF THE PELVIS

FOR descriptive as well as for practical purposes, it is useful to divide fractures of the pelvis into those which involve the integrity of the pelvic girdle as a whole, and those confined to individual bones.

In all, the prognosis depends upon the severity of the visceral lesions which so frequently complicate these injuries, rather than upon the fractures themselves.

Fractures implicating the pelvic girdle as a whole usually result from severe crushing forms of violence, such as the fall of a mass of coal or a pile of timber, or the passage of a heavy wheel over the pelvis. The force may act in the transverse axis of the pelvis, or in its antero-posterior axis. The pelvic viscera may be lacerated by the tearing asunder of the bones, or perforated by sharp fragments.

As a rule, more than one part of the pelvis is broken, the situation of the lesions and the clinical features varying in different cases.

Separation of the pubic symphysis may result from violence inflicted on the fork, as in coming down forcibly on the pommel of a saddle; from forcible abduction of the thighs; or it may happen during child-birth. In some cases the two pubic bones at once come into apposition again, and there is no permanent displacement, the only evidence of the injury being localised pain in the region of the symphysis elicited on making pressure over any part of the pelvis. In other cases the pubic bones

overlap one another, and the membranous portion of the urethra, or the bladder wall, is liable to be torn. The displaced bones may be palpated through the skin, or by vaginal or rectal examination.

The *pubic portion* of the pelvic ring is the most common seat of fracture. The bone gives way at its weakest points—namely, through the horizontal ramus of the pubes just in front of the pectineal eminence, and at the lower part of the descending ramus (Fig. 181). The intervening fragment of bone is isolated, and may be displaced. These fractures are frequently bilateral, and are often associated with separation of the sacro-iliac joint, with longitudinal fracture of the sacrum (Fig. 183), or with other fractures of the pelvic bones.



FIG. 181.—Fracture of Pelvis through Horizontal and Descending Rami of Pubes.

Injuries of the membranous urethra and bladder are frequent complications of these fractures. Less commonly the rectum, the vagina, or the iliac blood-vessels are damaged.

Localised tenderness at the seat of fracture, pain referred to that point on pressing together or separating the iliac crests, and mobility of the fragments with crepitus,

are usually present. The fragments may sometimes be felt on rectal or vaginal examination. As in all cases of pelvic fracture, shock is a prominent feature.

The *lateral and posterior aspects* of the pelvic ring may be implicated either in association with pubic fractures or independently. Thus a fracture of the iliac bone may run into the great sciatic notch; or a vertical fracture of the sacrum or separation of the sacro-iliac joint may break the continuity of the pelvic brim. In rare cases these injuries are accompanied by damage to the intestine, the rectum, the sacral nerves, or the iliac blood-vessels.

Treatment.—In all fractures of the pelvis it is of importance that the patient be moved and handled with great care,

lost fragments become displaced and injure the viscera. He should be put to bed on a firm mattress. Some surgeons prefer a mattress made in three pieces, for convenience in using the bed-pan and for the prevention of bed-sores, but we have not found this to be of any service in practice.

Before the treatment of the fracture is commenced, the surgeon must satisfy himself, by the use of the catheter and by other means, that the uterua and bladder are intact. Should these or any other of the pelvic viscera be damaged, such injuries must receive attention first.

The treatment of the fracture itself consists in adjusting the fragments, as far as possible by manipulation, applying a firm

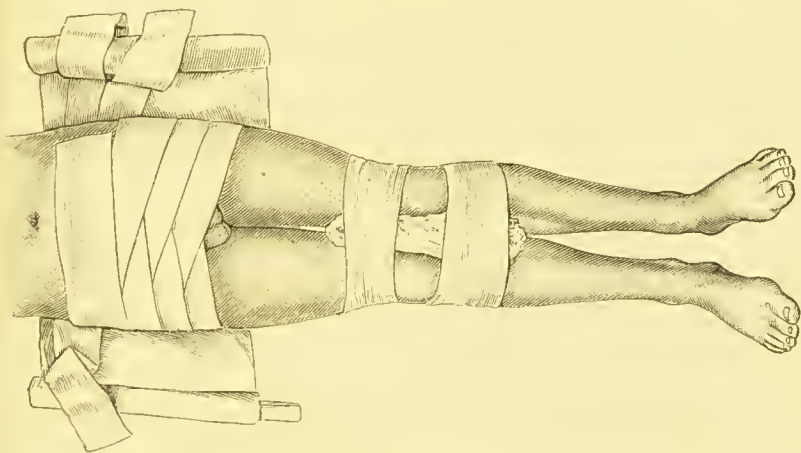


FIG. 182. -- Many-tailed Bandage and Binder for Fracture of Pelvic Girdle.

binder or many-tailed bandage round the pelvis, and fixing the knees together by a bandage (Fig. 182).

In some cases extension may be applied to both legs, with the limbs abducted and steadied by sand-bags.

Compound fractures, being commonly associated with extravasation of urine, are liable to septic complications. Loose fragments should be removed, as they are prone to undergo necrosis.

The patient is confined to bed for six or eight weeks, and it may be several weeks more before he is able to resume active employment.

The **acetabulum** may be fractured by force transmitted through the femur, from a fall on the feet, the knees, or the great trochanter. It may merely be fissured, or the head of the femur may be forcibly driven through its floor into the

pelvic cavity, either by fracturing the bone or, in young subjects, by bursting asunder the cartilaginous junction of the constituent bones. When the femoral head penetrates into the pelvis, the condition simulates a fracture of the neck of the femur, but the trochanteric region is more depressed, and the displaced head may be recognised on rectal or vaginal examination. The limb is shortened, the movements of the joint much restricted and painful, but crepitus is not always to be detected.

When the head of the femur penetrates the acetabulum, reduction should be attempted by traction and manipulation. After reduction, the treatment is the same as for fracture of the neck of the femur (Fig. 191). Reduction is often difficult, and sometimes impossible.

In addition to the fracture of the floor, it is necessary to mention a fracture of the *upper and back part of the rim* of the acetabulum which may accompany dorsal dislocation of the hip. Crepitus may be present in addition to the symptoms of dislocation, and after reduction the displacement is easily reproduced. This injury is liable to be mistaken for a fracture of the neck of the femur, but the flexion and internal rotation of the hip should prevent error. The treatment is the same as for fracture of the neck of the femur.

Fractures of Individual Bones of the Pelvis.—*Ilium.*—The expanded portion of the iliac bone is often broken by direct violence, the detached fragments varying greatly in size and position.

The whole or part of the *crest* may be separated by similar forms of violence.

When the fracture implicates the *ala* of the bone, it usually starts at the triangular prominence near the middle of the crest, and runs backwards or forwards, passing for a variable distance into the iliac fossa. The displaced fragment may sometimes be palpated and made to move when the muscles attached to it are relaxed. This is done by flexing the thighs and bending the body forward and towards the affected side. Pain and crepitus may be elicited on making this examination.

These fractures are treated by applying a roller bandage or broad strips of adhesive plaster over the seat of fracture, and by placing the patient in such a position as will relax the muscles attached to the displaced fragment—in the case of the iliac spines by flexing the thigh upon the pelvis; in the case of the crest or ala by raising the shoulders. Union takes place in three or four weeks.

In young persons, the *anterior superior spine* has been torn off and displaced downwards by powerful contraction of the sartorius muscle; and the *anterior inferior spine* by strong traction on the Λ -shaped ligament. These injuries are best treated by fixing the displaced fragment in position by pegs or silver-wire sutures and relaxing the muscles acting on it.

Fracture of the *ischium* alone is rare. It results from a fall on the buttocks, the entire bone or only the tuberosity being broken. There is little or no displacement, and the diagnosis is made by external manipulation and by examination through the rectum or vagina.

A longitudinal fracture of the *sacrum* may implicate the posterior part of the pelvic ring, as has already been mentioned. In rare cases the lower half of the bone is broken *transversely* from a fall or blow, and the lower fragment is bent forward so that it projects into the pelvis and may press upon or tear the rectum, or the sacral nerves may be damaged, and partial paralysis of the lower limbs, bladder, or rectum result. These fractures are frequently comminuted and compound, and the soft parts may be so severely bruised and lacerated that sloughing follows. On rectal examination the lower segment of the bone can be felt, and on manipulating it pain and crepitus may be elicited.



FIG. 183.—Longitudinal Fracture of Sacrum from same Patient as Fig. 181.

Fracture of the *coccyx* may be due to a direct blow, or may occur during parturition. As a result of this injury the patient may have severe pain on sitting or walking, and during defecation. The loose fragment can usually be palpated on rectal examination. There is considerable difficulty in keeping the fragment in position, and if it projects towards the rectum it should be removed. If the lower fragment unites at an angle so as to cause pressure on the rectum, it gives rise to the symptoms of *coccydynia*, which may call for excision.

INJURIES IN THE REGION OF THE HIP

These include the various fractures of the upper end of the femur; dislocations and sprains of the hip-joint; and contusions of the hip.

Surgical Anatomy.—The strength of the hip-joint depends primarily on its osseous elements—the rounded head of the femur filling the deep socket of the acetabulum, to the bottom of which it is attached through the medium of the ligamentum teres. The edge of the acetabulum is specially strong above and behind, while at its lower margin there is a gap, bridged over by the cotyloid ligament.

In relation to fractures of the upper end of the femur, it is to be borne in mind that as the antero-posterior diameter of the neck is less than that of the shaft, and as a considerable portion of the great trochanter lies behind the junction of the neck with the shaft, the greater part of any strain put upon the upper end of the femur is borne by the neck of the bone and not by the trochanter. The head and neck of the femur

are nourished chiefly by the thick, vascular periosteum, and through certain strong fibrous bands reflected from the attachment of the capsule—the cervical ligaments of Stanley. The integrity of these ligaments plays an important part in determining union in fractures of the neck of the femur, both by keeping the

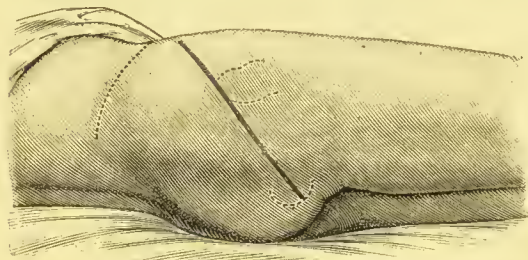


FIG. 184.—Nèlaton's Line.

fragments in position and by maintaining the blood-supply to the short fragment. Whether it be true or not that an alteration in the angle of the femoral neck takes place with advancing years, it is generally recognised that this change is of no importance in relation to fractures in this region.

The capsular ligament of the hip is of exceptional strength. It is attached above to the entire circumference of the acetabulum, and below to the neck of the femur in such a way that while the whole of the anterior and inferior aspects of the neck lie within its attachment, only the inner half of the posterior and superior aspects is intra-capsular. The capsule is augmented by several accessory bands, the most important of which is the *ilio-femoral* or *λ-shaped ligament* of Bigelow, which passes from the anterior inferior iliac spine to the anterior inter-trochanteric line, its fasciculi being specially thick towards the upper and lower ends of this ridge. The inner limb of this ligament limits extension of the thigh, while the outer limits eversion and adduction. The weakest part of the capsular ligament lies opposite the lower and back part of the joint.

The hip-joint is surrounded by muscles which contribute to its strength, the most important from the surgical point of view being the obturator internus, which plays an important part in certain dislocations, and the ilio-psoas, which influences the attitude of the limb in various lesions in this region.

Except in very thin subjects, the constituent elements of the hip-joint cannot be palpated through the skin. A line drawn vertically downwards from the middle of Poupart's ligament passes over the centre of the joint, which, in adults, lies on the same level as the tip of the great trochanter. In children it is somewhat higher.

For purposes of clinical diagnosis it is necessary to locate certain bony prominences, the most important being:—(1) The *anterior superior iliac spine*, which is most readily recognised by running the fingers along Poupart's ligament from within outwards. (2) The *ischial tuberosity*, which in the extended position of the limb is overlapped by the lower margin of the gluteus maximus muscle, and is therefore not easily located with precision. By flexing the limb and making pressure from below upwards in the gluteal fold, the smooth, rounded prominence can usually be detected. (3) The *quadrilateral great trochanter* is readily recognised on the outer aspect of the hip. Its highest point or *tip* can best be felt by pressing over the gluteal muscles from above downwards.

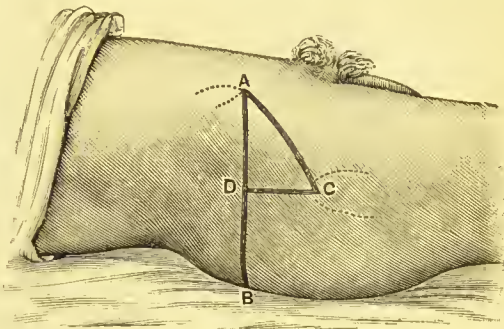


FIG. 185.—Bryant's Lines.

Clinical Tests.—If a line is drawn from the anterior superior iliac spine to the most prominent part of the ischial tuberosity, it just touches the tip of the great trochanter. This is known as *Nélaton's line* (Fig. 184).

Bryant's test (Fig. 185) is applied with the patient lying on his back, and consists in dropping a perpendicular AB from the anterior superior iliac spine, and drawing a line CD from the tip of the great trochanter to intersect the perpendicular at right angles. This is done on both sides of the body, and the length of the lines CD compared. Shortening on one side indicates an upward displacement of the trochanter, lengthening a downward displacement. The third side AC of the triangle indicates the distance between the anterior spine and the tip of the trochanter.

Chiene's test, which is simpler than either of these, consists in applying a strip of lead or tape across the front of the body at the level of the anterior superior iliac spines, and another touching the tips of the two trochanters. Any want of parallelism in these lines indicates a change in the position of one or other trochanter.

FRACTURES OF THE UPPER END OF THE FEMUR

It will be convenient here to study the various fractures of the upper end of the femur that are liable to be confused with one another and with dislocations of the hip. These include fractures of the head, the neck, the trochanters, and separation of the upper epiphyses, and fracture of the shaft just below the trochanters.

Fracture of the **head of the femur** is exceedingly rare, and is usually a complication of backward dislocation of the hip. It takes the form of a split of the articular surface caused by impact against the edge of the acetabulum, and is analogous to

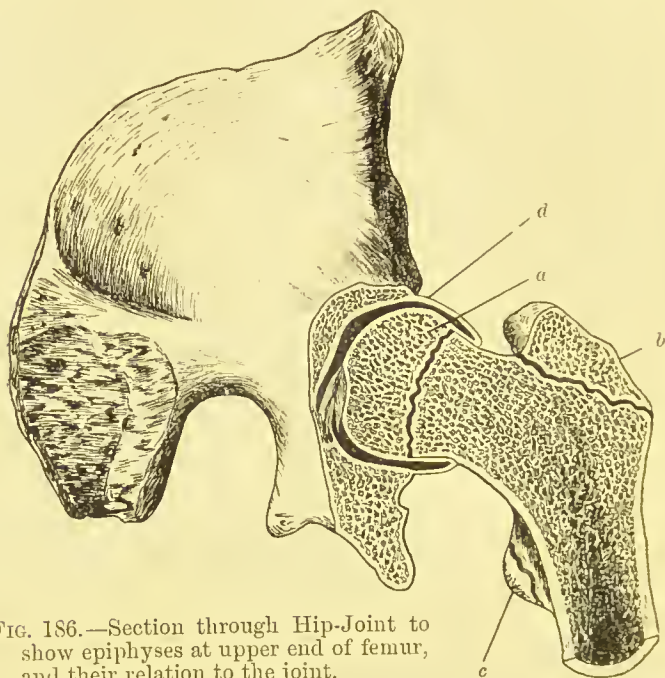


FIG. 186.—Section through Hip-Joint to show epiphyses at upper end of femur, and their relation to the joint.

a, Epiphysis of head. *b*, Epiphysis of great trochanter. *c*, Epiphysis of small trochanter. *d*, Capsular ligament.

(After Poland.)

the indentation fracture of the head of the humerus, which may accompany dislocation of the shoulder.

The **epiphysis of the head**, which lies entirely within the capsule of the joint (Fig. 186), is occasionally separated, and the symptoms closely simulate those of fracture of the narrow part of the neck. If the condition is overlooked or imperfectly treated, it may in course of time be followed by coxa vara.

FRACTURES OF THE NECK

It has long been customary to divide fractures of the neck of the femur into two groups—"intra-" and "extra-capsular"; but as in a considerable proportion of cases the line of frac-

ture falls partly within and partly without the capsule, this classification is wanting in accuracy. It is more correct to divide these fractures into (1) those occurring *through the narrow part of the neck*, which are nearly always purely intra-capsular; and (2) those occurring *through the base of the neck*, in which the line of fracture lies inside the capsule in front, but outside of it behind.

It is of considerable importance to distinguish between fractures in these two positions. The first group occurs almost



FIG. 187.—Fracture through Narrow Part of Neck of Femur on section.
The neck of the bone has undergone absorption.

exclusively in old persons as a result of slight forms of indirect violence, and it is liable, on account of the feeble vascular supply to the upper fragment, to be followed by absorption of the neck, which delays or may even entirely prevent union (Fig. 187). The second group usually occurs in robust adults, and results from severe forms of violence applied to the trochanter. In this group firm osseous union usually takes place.

Fracture of the Narrow Part of the Neck or Intra-capsular Fracture.—This fracture is most frequently met with in elderly

persons, especially in women, and is usually produced by comparatively slight forms of indirect violence—such, for example,



FIG. 188.—Impacted Fracture through Narrow Part of Neck of Femur.

as result from the foot catching on the edge of a carpet, a stumble in walking, or missing a step in going down stairs.



FIG. 189.—Fracture of Neck of Right Femur, showing shortening abduction, and eversion of limb.

The line of fracture, which is usually transverse but may be oblique or irregular, lies for the most part within the capsule, and the posterior part of the neck is more comminuted than the anterior. The outer fragment, which includes the base of the neck, the trochanters, and the shaft, is usually displaced upward and rotated outward. If the periosteum and the cervical ligaments remain intact, displacement is prevented and union favoured.

Impaction is less common than in fracture through the base of the neck; it usually results from the patient falling on the trochanter, the outer fragment being driven as a wedge into the inner (Fig. 188).

Clinical Features.—In non-impacted cases the limb is at once rendered useless, and the patient is unable to rise. There is pain and tenderness in the region of the hip on making the slightest movement; and a specially tender spot may be localised, indicating the seat of fracture.

On placing the pelvis as square as possible, and comparing the measurements of the limbs from the anterior superior spine to the internal malleolus, shortening of the injured limb to the extent of from one to three inches may be found. On applying Nélaton's, Bryant's, or Chiene's tests, the tip of the great trochanter will be found elevated. It is also farther back and less prominent than normal.

The whole limb is usually everted to a greater or less degree, and is slightly abducted. In some cases, when the impaction is of the anterior portion of the neck, the limb is inverted. On comparing the ilio-tibial band of the fascia lata on the two sides, it is found to be relaxed on the side of the injury.

The violence being as a rule indirect, there is at first little or no discoloration in the vicinity of the hip, but this may appear a few days later.

Crepitus is not a constant sign, and should not be diligently sought for, as the necessary manipulations are liable to disengage the fragments and to increase the deformity. For the same reason rotatory movements are to be avoided. It is often stated that when the neck of the femur is broken, the trochanter may be recognised to rotate through the arc of a smaller circle than under normal conditions. Theoretically this may be true, but the difference is so slight as to render the sign of little clinical value.

In all cases in which the diagnosis is uncertain, the patient should be put to bed, and treated as for a fracture. In the

course of a few days, when the swelling has subsided and the pain abated, a further examination should be made, and the subsequent treatment determined by the result.

In examining an old person who has sustained an injury in the region of the hip, it should be borne in mind that the limb may be shortened and everted as a result of arthritis deformans, and that the symptoms of that disease may simulate those of fracture. In arthritis deformans, however, the ilio-tibial band of the fascia lata is not relaxed as it is in fracture.

In some cases, and particularly in those in which the periosteum of the neck and the cervical ligaments remain intact, the shortening does not become apparent till a few days after the accident. As the other symptoms are correspondingly obscure, the condition is apt to be mistaken for a bruise. In all doubtful cases the part should be examined from day to day, and, if possible, the X-rays should be used.

In *impacted* cases the signs of fracture are often obscure, and the patient may even be able to walk after the accident. The skin over the trochanter is generally discoloured from bruising. Eversion is usually present, but there may be very little shortening. Crepitus is absent. In old people it is never advisable to undo impaction, as the interlocking of the bones favours the occurrence of osseous union.

Prognosis.—A fracture of the neck of the femur in an old person is always attended with danger to life, a considerable proportion of the patients dying within a few weeks or months of the accident from causes associated with it. In some cases the mental and physical shock so far diminishes the vitality of the patient that death ensues within a few days. It is possible that fat embolism may account for death in some of the more rapidly fatal cases. In others, the continued dorsal position induces hypostatic congestion of the lungs, or, owing to the difficulties of nursing, bed-sores may form and death result from septic absorption. Frequently the prolonged confinement to bed, the continuous pain, and the natural impairment of appetite wear out the strength. In many cases the patient becomes pceevish, irritable, or mentally weak.

Osseous union is the exception in intra-capsular fracture, especially when the periosteum and the cervical ligaments have been completely torn, but in sub-periosteal and in impacted fractures it sometimes occurs. As a rule, however, the neck of the femur becomes absorbed and disappears, the head of the bone comes to lie in contact with the base of the trochanter, and a false joint forms (Fig. 187). Chronic changes of the

nature of arthritis deformans may occur in and around such false joints.

When osseous union fails to take place, although the patient may eventually be able to get about, he can do so only with the aid of a stick or crutch, and as there is marked shortening, he walks with a decided limp. There is considerable antero-posterior thickening of the neck of the femur, and the femoral vessels may be pushed forward in Scarpa's triangle.

Treatment.—In treating a fracture through the narrow part of the neck, it is necessary to consider the age and general condition of the patient; whether the fracture is impacted or not; and the site of the fracture—whether in the narrow part of the neck or at its base. "The first indication is to save life, the second to get union, and the third to correct or diminish displacements" (Stimson).

In old and debilitated patients, bony or even firm fibrous union seldom takes place, and it is generally advisable to get them out of bed as speedily as possible. For the first few days the patient may be kept on his back, the limb massaged daily, and in the interval steadied by sand-bags; but on the first sign of respiratory or cardiac trouble he should be propped up in bed, and as soon as possible lifted into a chair. In all such cases care should be taken to avoid undoing impaction.

When the general condition of the patient permits of it, an attempt should be made to secure bony union by one or other of the following appliances.

It has been shown by Royal Whitman that the most accurate apposition of the fragments is obtained when the limb is placed



FIG. 190.—Fracture of Narrow Part of Neck of Femur. The neck has become absorbed, the head has not united, and a false joint has formed.

in the position of extreme abduction, steadied between two long narrow sand-bags.

Shortening may be counteracted by *extension with weight and pulley* (Fig. 191). Strips of strong adhesive plaster are applied to each side of the limb, reaching well above the middle of the thigh. To the lower ends of these are attached broad tapes, to which a stirrup is buckled, and through it traction is made by means of a cord passing over a pulley fixed to the corner of the bed, the weight varying with the requirements of the case. In a moderately muscular adult, a weight of from six to eight pounds should be applied at first, and increased or diminished as required. The correct weight to employ is that which maintains the length of the limb at its normal. In some cases

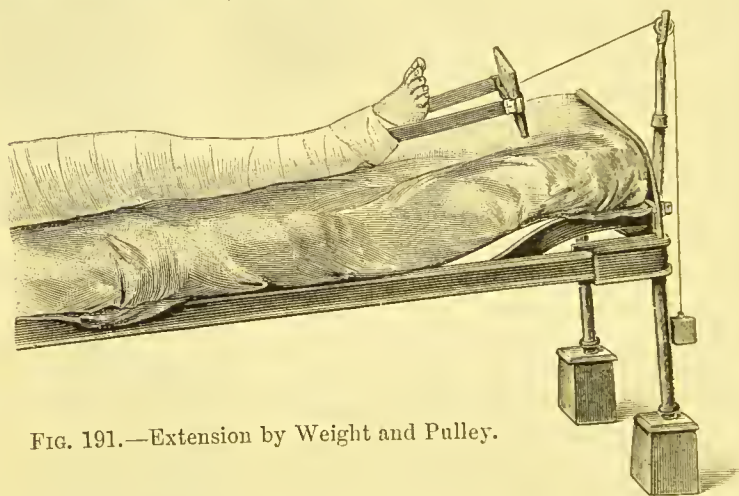


FIG. 191.—Extension by Weight and Pulley.

it may be necessary to use as much as fifteen pounds. The necessary counter-extension is obtained by raising the foot of the bed on blocks.

Steinmann's apparatus (Fig. 192) may be had recourse to when more powerful extension is required to maintain the normal length of the limb; two steel pins are driven into the lower end of the femur, one on either side, and through these, extension by weight amounting to as much as forty or fifty pounds may be exerted on the lower fragment.

Should it be considered necessary to control the joints above and below the fracture, this may be done by means of *Liston's long splint* (Fig. 193), which extends from the axilla to two or three inches beyond the foot. The part of the splint which lies in contact with the lower extremity is enclosed in a sheet,

which envelops the limb, while the upper part is fixed to the thorax by means of a broad roller bandage. To enable the limb to be abducted, the splint should be furnished with a hinge placed opposite the hip-joint (Fig. 288). Rotation of the limb is prevented by fixing the lower end of the splint in a foot-rest. In restless patients it is an advantage to apply a long splint to the sound leg in addition, and to connect the two splints by a cross-bar below.

Eversion may be corrected by sand-bags placed alongside the limb, or by means of a piece of wood fixed to the back of the knee at right angles to the axis of the limb by a few turns of plaster-of-Paris bandage. It is important also to keep the bed-clothes clear of the foot by means of a cage.

Hodgen's splint is one of the most comfortable and efficient means of treating these fractures, as it allows the patient a certain amount of movement, admits of the part being massaged, and facilitates nursing.

It consists of a wire frame (Fig. 194), to one side of which a series of strips of flannel about four inches wide are attached. Extension strapping is first applied, and then the frame, which extends from the level of Poupart's ligament to well beyond the sole, is placed over the front of the limb, and the loose ends of the flannel strips, brought round behind the limb, and fixed to the other side of the frame, convert it into a sling.

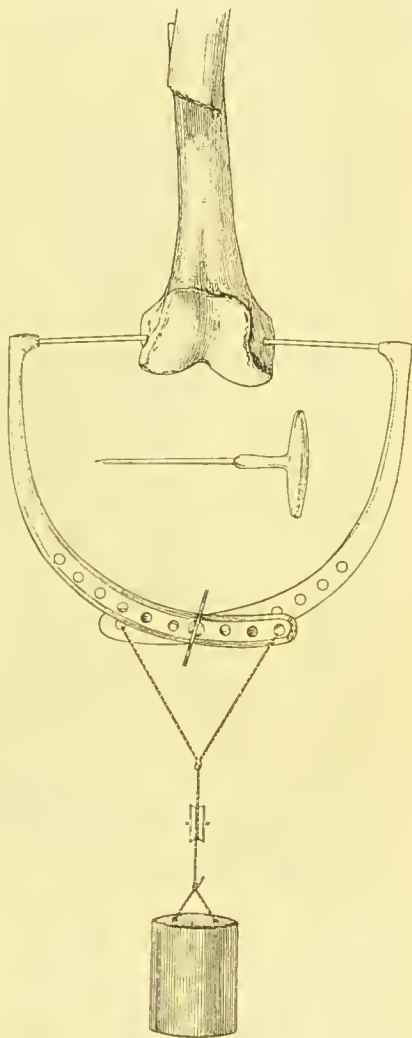


FIG. 192.—Steinmann's Apparatus for applying Direct Extension to the Femur.

The strips of flannel may be replaced with advantage by a strong, wide-meshed net. The tapes attached to the extension strapping are now tied to the end of the frame. By suspending the limb in this splint by means of cords passing obliquely over a pulley attached to an upright at the foot of the bed, the

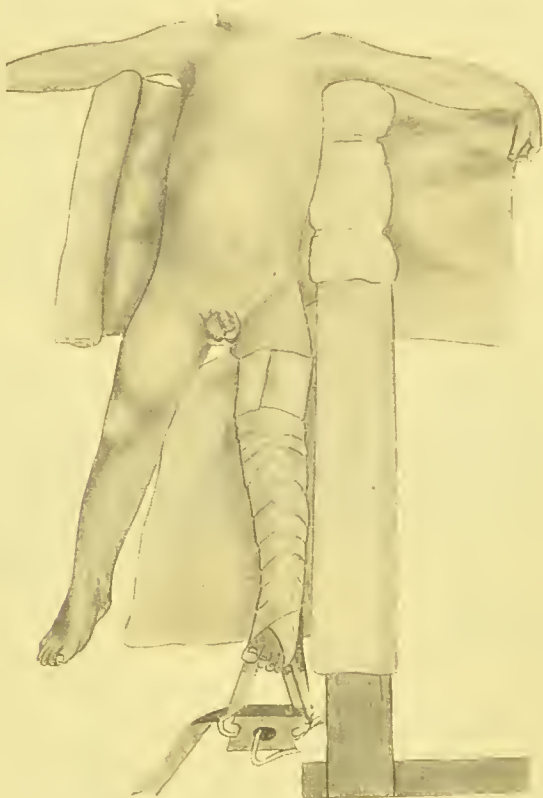


FIG. 193.—Long Splint with Extension Plasters applied for Fracture of Neck of Femur.

weight of the limb is made to act as the extending force. It should be kept on for six or eight weeks, after which the patient is allowed to walk on crutches for three or four weeks longer.

In exceptional cases, recourse may be had to accurate fixation of the fragments by a long steel peg introduced through the skin over the great trochanter, and passed so as to transfix them; or the fragments may be exposed by an open operation and sutured together with silver wire, the torn capsule being stitched with catgut.

As a *temporary means of securing the limb*—for example, while the patient is being transported to hospital—extension may be obtained by means of a *perineal band* attached to *Liston's long splint* (Fig. 195). The patient's foot, carefully padded, is fixed to the lower end of the splint by a bandage or triangular handkerchief. By pushing the splint down, traction is made upon the limb, and this is maintained by

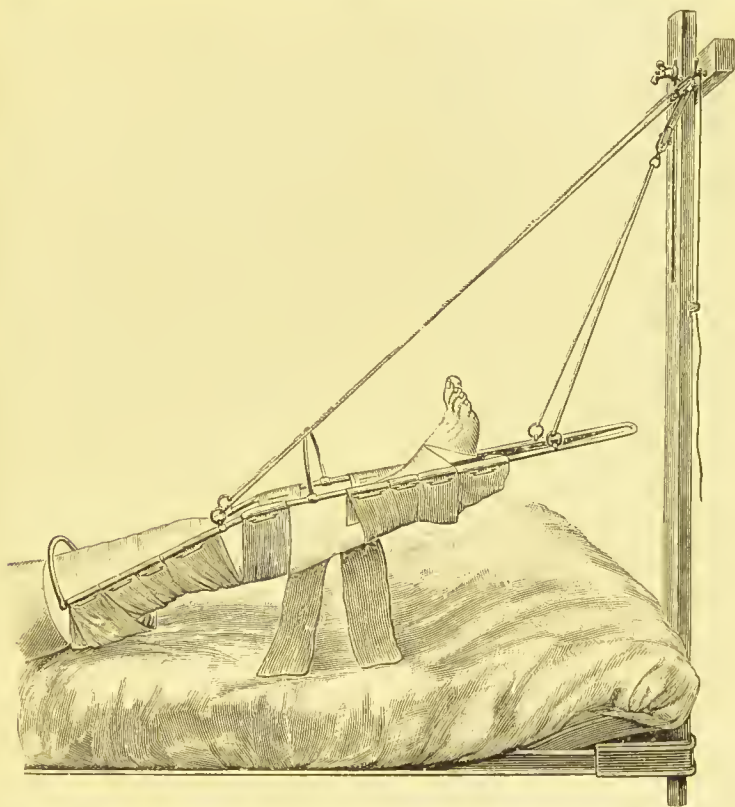


FIG. 194.—Hodgen's Splint.

means of a padded triangular bandage passed through the fork, and fixed to the upper end of the splint.

Fracture of the Neck of the Femur in Children.—The use of the X-rays has shown that this fracture is comparatively common in children, as a result of a fall or a forcible twist of the leg. The fracture is most frequently of the greenstick variety; when complete, it is usually impacted. There is shortening to the extent of a half or three-quarters of an inch, a slight degree of eversion, the movements of the hip are restricted, and there is some pain. The patient is often able

to move about after the accident, but walks with a limp. Unless the use of the X-rays reveals the fracture, the condition is liable to be overlooked.

When the lesion is diagnosed, the deformity should be completely corrected, any impaction that exists being undone; and the limb is put up in a wide abduction splint or in a plaster-of-Paris cast in the position of extreme abduction.

If the condition is not recognised and treated, it is liable to be followed by the development of coxa vara (Royal Whitman) (Fig. 196).

Fracture through the Base of the Neck.—This fracture is usually produced by a fall on the great trochanter, although it is occasionally due to a fall on the feet or knees.

Although often spoken of as "extra-capsular," on account of the disposition of the capsular ligament already described, the line of fracture is generally partly within and partly without the capsule. The fracture usually lies close to the junction of the neck with the shaft, and in the great majority of cases is accompanied by breaking of one or both trochanters. This is due to the neck being driven as a

wedge into the trochanters, splitting them up. When the fragments remain interlocked, the fracture is of the *impacted* variety (Fig. 198).

Clinical Features.—Although this fracture is commonly met with in strong adults, it may occur in the aged.

The outer aspect of the hip shows marks of bruising, and there is always severe pain and a considerable degree of shock.



FIG. 195.—Long Splint with Perineal Band.

The limb lies helpless; there is generally marked eversion, with shortening, which, in *non-impacted* cases, may amount to



FIG. 196.—Coxa Vara following Fracture of Neck of Femur in a child.
(Mr. Robert Jones' case. Radiogram by Dr. D. Morgan.)

one and a half or two inches, and is evident immediately after the accident; it is due to the lower fragment being drawn up

by the muscles inserted into the great trochanter and upper end of the shaft. In a limited number of cases the outer fragment lies in front of the inner, and there is inversion of the limb.

On applying the various tests, the great trochanter is found to be displaced upwards, there is some antero-posterior broadening of the trochanteric region, and the ilio-tibial band is relaxed. On pressing the fingers into the outer part of Scarpa's triangle, a bony mass consisting of the broken fragments may be felt, and is tender on pressure. Unnatural mobility with crepitus may be elicited.



FIG. 197.—Non-impacted Fracture through Base of Neck.

In the *impacted variety*, the shortening seldom exceeds one inch; the eversion is less marked; there is some power of voluntary movement; and crepitus is absent. The broadening of the trochanteric region is greater, and the great trochanter is approximated to the acetabulum.

Prognosis.—The risks to life in the aged are similar to those of intra-capsular fracture. In youths and healthy adults the chief danger is that the limb may be shortened and its function thereby impaired.

As the periosteum and cervical ligaments which transmit the blood-vessels to the short fragment are intact, bony union is the rule. There is always, however, considerable thickening in the region of the trochanter due to displaced fragments

and callus, and in a certain number of cases, even with the greatest care in treatment, there is a varying degree of shortening and eversion of the limb. In cases in which the outer fragment lies in front of the inner there is permanent inversion.

Treatment.—As this fracture usually occurs in robust patients, there is no danger from prolonged confinement to bed; and as union without deformity can be attained in no other way, this is always advisable. When the shortening and

eversion are excessive, they should be completely corrected under anæsthesia before the retentive apparatus is applied, any impaction that exists being undone. When the deformity resulting from impaction is slight, however, it is best to leave it, as it facilitates speedy and firm union.

The same retentive appliances are used as in fracture through the narrow part of the neck (p. 564).

Fracture of the **great trochanter** occurring apart from fracture of the neck usually results from direct violence, but may be due to muscular action. The trochanter is displaced by the gluteal muscles, causing broadening of the outer aspect of the hip. In young persons the epiphysis of the great trochanter may be separated, but this is rare. The treatment consists in retaining the fragments in position by keeping the limb abducted between sand-bags, or by pegs driven in through the skin.

Fracture immediately below the lesser trochanter

may be produced by direct or by indirect violence, and the displacement depends largely on whether the line of fracture is transverse or oblique. The upper fragment is tilted forward and rotated outward by the ilio-psoas muscle and the external rotators inserted in the region of the great trochanter. The lower fragment is pulled upward and rotated outward by the flexors and adductors, the weight of the limb aggravating the eversion. The tilting of the upper fragment may be increased by the displaced lower fragment pushing it forward.

On account of the difficulty of controlling the short upper



FIG. 198.—Fracture through Base of Neck of Femur with Impaction into the Trochanters.

fragment, union is liable to take place with considerable shortening and deformity (Fig. 200).

Treatment.—When it is found, under an anæsthetic, that the displacement can be completely reduced, and does not tend to recur, this fracture is treated on the same lines as fractures of the shaft of the bone.

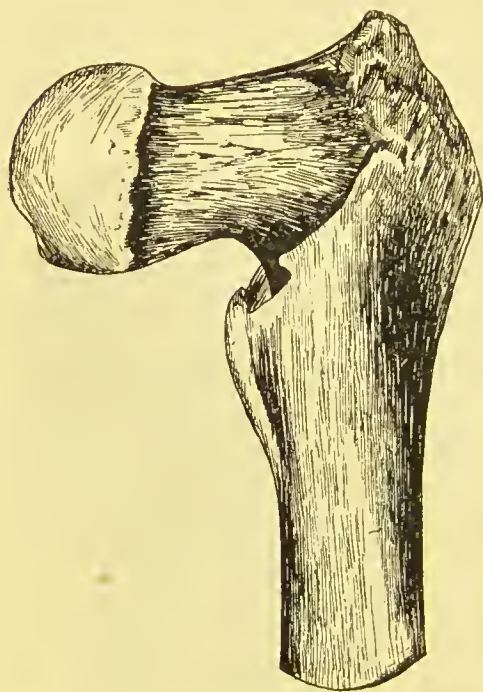


FIG. 199.—Non-impacted Fracture through Base of Neck. Union has occurred with diminution of angle of neck—Coxa Vara.

In cases in which the upper fragment cannot be brought into line with the lower one, however, it is necessary to flex and slightly rotate outward and abduct the thigh in order to get the fragments into apposition. This is most simply done by means of a double-inclined plane (Fig. 201), while at the same time extension may be applied in the axis of the thigh.

Hodgen's splint (Fig. 194) fulfils these indications, and it has the advantage of permitting of the patient being

moved or even propped up in bed without fear of disturbing the fracture.

In all these fractures of the upper end of the femur, massage should be employed from the outset, and movements as soon as possible.

DISLOCATIONS OF THE HIP

It is unnecessary for our present purpose to attempt a comprehensive classification of the numerous varieties of dislocation that have been met with at the hip-joint. It will suffice if we divide them into those in which the head of the femur passes backward, and comes to rest on the dorsum ilii, or in the vicinity of the ischiatic notch; and those in which it

passes forward and comes to rest in the obturator foramen, or on the pubes (Fig. 202).

The backward are much more common than the forward dislocations, in contrast to what obtains at the shoulder, where the forward varieties predominate.

On account of the great strength of the hip-joint, dislocation is by no means a common injury. It occurs most frequently in strong adults after the epiphyses have ossified, and before the bones have commenced to become brittle; and it is much more common in men than in women. It is invariably the result of severe violence, the limb at the moment being in such a position that the ligaments are on the stretch and the muscles taken at a disadvantage. The head of the femur usually leaves the joint at the lower and back part, where the socket is most shallow and the ligaments weakest. The ligamentum teres is almost always torn from its femoral attachment, and one or more of the muscles inserted in the region of the trochanters may be ruptured. The Λ -shaped ligament, on the other hand, is seldom torn, and so long as it remains intact the dislocation belongs to one or other of the types above named. All atypical dislocations, such as the supra-cotyloid, infra-cotyloid, ilio-pectineal, are due to rupture of some part of the Λ -ligament, and are so rare as not to call for individual description.

Like other dislocations, those of the hip may be complicated by laceration of muscles, blood-vessels, or nerves, or by fracture of one or other of the bones in the vicinity.

Dislocation on to the Dorsum Ilii.—This, the commonest form of dislocation of the hip, is usually the result of the patient falling from a height, or receiving a heavy weight on the back while stooping forward with the thigh flexed, slightly adducted, and rotated in. It is also said to have occurred from muscular action. The shaft of the femur acts as the long limb of a lever of which the neck is the short limb, the femoral attachment of the Λ -ligament forming the fulcrum. The head,



FIG. 200.—Fracture of Femur just below the Small Trochanter united, showing flexion and external rotation of upper fragment.

thus brought to bear upon the lower and back part of the capsule, tears it and leaves the socket, passing upwards and coming to rest on the dorsum of the ilium, above and anterior to the tendon of the obturator internus (Fig. 204). The articular surface is directed backward, while the trochanter looks forward.

Clinical Features.—The affected limb is flexed, adducted, and rotated inward, so that the knee crosses the lower third of the opposite thigh, and the ball of the great toe lies on the dorsum of the sound foot. There is shortening to the extent of from one and a half to two inches, the trochanter being displaced above Nélaton's line, and lying nearer to the anterior superior iliac spine than on the normal side. The

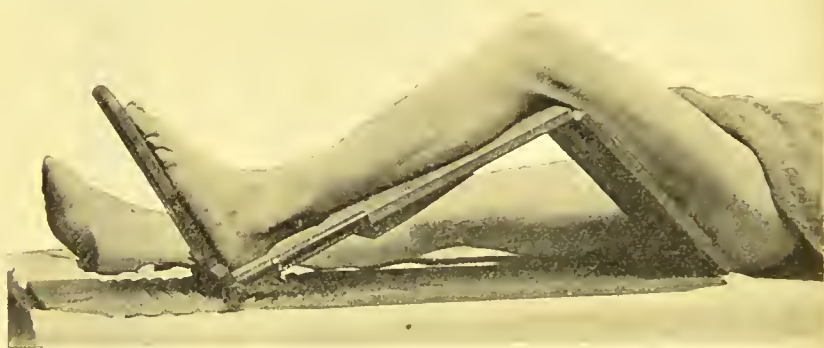


FIG. 201.—Adjustable Double-inclined Plane.

patient is unable to move the limb or to bear weight upon it; abduction and external rotation are specially painful; and traction fails to restore the limb to its proper length. On making these attempts a characteristic elastic resistance is felt.

The head of the femur in its new position may sometimes be felt through the fibres of the gluteus maximus, but swelling of the soft parts often obscures this sign. The normal depression behind the great trochanter is lost, the gluteal fold is raised, and there is often a degree of lordosis which compensates for the flexion. The fingers can be pressed more deeply into Scarpa's triangle on the dislocated than on the normal side—a point in which this injury differs from fracture of the base of the neck of the femur.

In a certain number of cases the outer limb of the Λ -ligament is ruptured and the limb is everted—*dorsal dislocation with eversion*.

Dislocation into the vicinity of the Ischiatic Notch, or

"*dislocation below the tendon.*"—This variety of backward dislocation is less common than that on to the dorsum, although produced in the same way. The head of the femur passes beneath the obturator internus, and this tendon, catching on its neck, checks its upward movement (Fig. 204).

The *clinical features* are the same as those of the dorsal variety, but, on the whole, are less marked.

Differential Diagnosis.

—Backward dislocations of the hip are usually easily recognised. When dislocation below the tendon occurs in a very stout person, however, it is liable to be overlooked on account of the difficulty of feeling the displaced bone, and of the comparatively slight amount of deformity present. The nature of the accident, the absence of broadening of the trochanter, and the adduction and inversion of the limb are usually sufficient to prevent a dislocation being mistaken for an impacted extra-capsular fracture.

Dislocation into the Obturator Foramen (Fig. 202).—This dislocation is

produced by great force applied from behind while the thigh is flexed and abducted, as when a weight falls on the back of a man stooping forward with the legs wide apart. It may also result from violent abduction by wide separation of the thighs.

The capsule gives way at its inner and lower part, and the head of the femur comes to rest on the surface of the external obturator muscle, its articular surface looking forward, while the trochanter looks backward.

Clinical Features.—In the standing position the thigh is slightly flexed and abducted, with the foot pointing directly forward or a little outward. The body is bent forward to

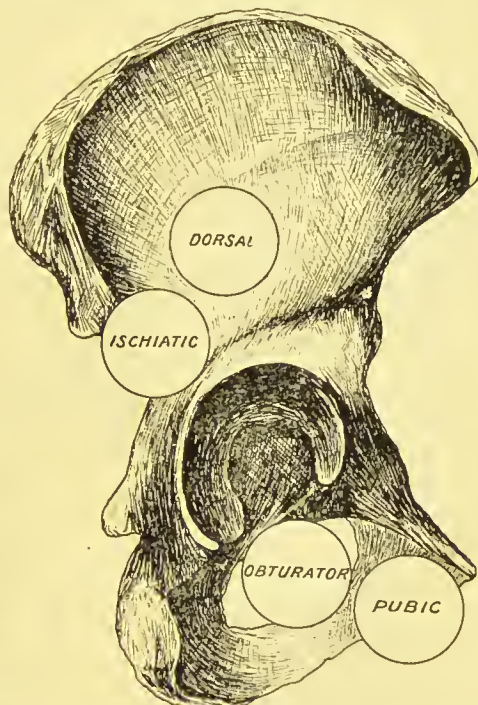


FIG. 202.—Diagram of the most common Dislocations of the Hip.

relax the ilio-psoas muscle and the Δ -ligament, the foot is advanced and the heel drawn up. It is not uncommon for the patient to be able to walk after the accident, and only to seek advice some time after on account of inability to adduct and extend the limb. There is apparent lengthening of the limb due to tilting of the pelvis downward on the affected side. The hip is flattened, the trochanter less prominent than usual, and the head of the bone may sometimes be felt in its abnormal position.

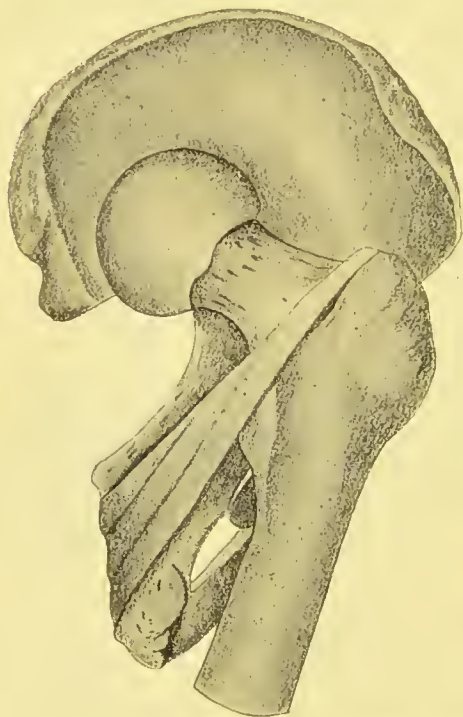


FIG. 203.—Dislocation on to Dorsum Ilii.
Note relation of neck of femur to tendons of obturator internus and gemelli.

Dislocation on to the pubes is a further degree of the obturator form (Fig. 202). It is usually produced by forcible hyper-extension and external rotation of the hip, such as occurs when the body is bent back while the thigh remains fixed.

The capsule is torn farther forward than in the other varieties, and the head rests on the horizontal ramus of the pubes against the ilio-pectineal line.

Clinical features.—There is marked eversion, flexion, and abduction, but the shortening is inconsiderable. The ilio-psoas and Δ -ligament are tense. The head of the femur

may be felt in the groin, with the femoral vessels over, or to one or other side of it. There is sometimes pain and numbness in the distribution of the anterior crural nerve. The prominence of the great trochanter is lost.

Treatment of Dislocations of the Hip.—For the reduction of a dislocation of the hip complete anæsthesia is necessary, and the patient should be placed on a firm mattress on the floor, to give the surgeon the best possible purchase upon the limb. The surgeon grasps the ankle with one hand, while the other is placed behind the head of the tibia, the leg being held at right

angles to the thigh. An assistant meantime steadies the pelvis by making firm pressure over the iliac crests.

As the chief obstacle to reduction is the tension of the ilio-femoral ligament, the first indication is to relax this structure by acutely flexing the hip.

In the *backward* varieties (dorsal and ischiatic) the Δ -ligament is relaxed by flexing the thigh upon the pelvis in the position of adduction. The thigh is then fully abducted, to cause the head of the bone to retrace its steps forwards towards the rent in the capsule; and at the same time rotated outwards, to relax the rotator muscles. This combined movement tends also to open up the rent in the capsule. Finally, the limb is quickly extended to cause the head to enter the socket. This object is often aided by making vertical traction or lifting movements on the abducted and externally rotated limb before extending.

For the reduction of the *forward* varieties (obturator and pubic), the thigh is first fully flexed on the pelvis, but in the abducted position. The limb is then strongly rotated inward and adducted, and finally extended. Lifting movements may be found useful in these cases also.

All methods of reduction by forcible traction on the extended limb are to be avoided, as they fail to meet the primary indication of relaxing the Δ -ligament.

After reduction, the limb is steadied by sand-bags; massage is carried out from the first, and movement after a few days. The range of movement is gradually increased, and the patient is allowed to use the limb with caution in from two to three weeks.

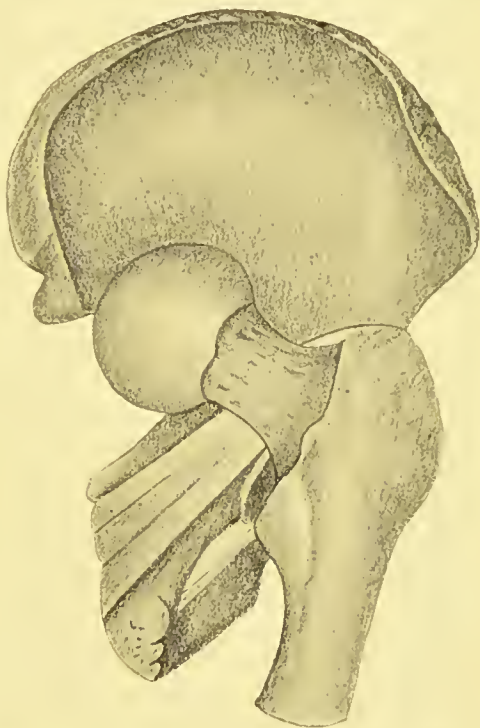


FIG. 204.—Dislocation into the vicinity of the Ischiatic Notch. Note relation of neck of femur to tendons of obturator and gemelli, "Dislocation below the tendon."

When the rim of the acetabulum has been fractured, the patient must be confined to bed with extension for six to eight weeks, to avoid the risk of re-dislocation.

Changes of the nature of chronic arthritis are liable to occur in and around the joint in old and rheumatic subjects; and atrophy or paralysis of muscles may follow, if their nerves are injured.

Old-standing Dislocations.—It is impossible to lay down any time-limit for attempting reduction in old-standing dislocations of the hip. Manipulation may succeed in cases of some months' standing, and may fail when the bone has been out only a few weeks. In certain cases, even after reduction has been effected, there is a marked tendency to re-displacement. In any case, the attempt does good by breaking down adhesions, provided no undue force is employed such as may damage the sciatic nerve or vessels, or fracture the neck of the femur, and success may attend on a second or even a third attempt at intervals of from three to five days. If manipulation fails, and if the deformity is great and the usefulness of the limb seriously impaired, an attempt may be made to effect reduction by operation, the head of the bone being excised if necessary; but if the head has formed a new socket for itself and there is a fairly useful joint, the condition should be left alone.

Congenital Dislocations of the Hip are described with Deformities.

Sprains of the hip are comparatively rare. They result from milder degrees of the same forms of violence as produce dislocation. The ligaments are stretched or partly torn, and there is effusion of fluid into the joint. Pressure over the joint elicits tenderness; and the limb assumes the position of slight flexion, abduction, and external rotation, but there is no alteration in the length of the limb. Such injuries, unless carefully treated by massage and movement from the outset, are apt to be followed by the formation of adhesions, resulting in stiffness of the joint.

Contusions in this region, on the other hand, are not uncommon. They are produced by a fall on the trochanter, and give rise to symptoms which simulate to some extent those of fracture of the neck. The limb lies in the position of slight flexion, but the bony points retain their normal relationship to one another, and there is no shortening. The swelling and tenderness often prevent a thorough examination being made, and when any doubt remains as to the diagnosis, the patient should be kept in bed till the doubt is cleared up. If the

bone has been broken, this will reveal itself in the course of a few days by the occurrence of shortening and other evidences of fracture.

In elderly patients, contusions of the hip may be followed by changes in the joint of the nature of arthritis deformans; and it has been stated, although proof is wanting, that absorption of the neck of the femur sometimes occurs. These injuries are treated by rest in bed, massage, and the other measures already described as applicable to sprains and contusions.

FRACTURES OF THE SHAFT OF THE FEMUR

This group includes all fractures between that immediately below the trochanter minor and the supra-condylar fracture.

In adults, when due to direct violence, the fracture is usually transverse, and may be attended with comparatively little displacement. Indirect violence, on the other hand, usually produces oblique fractures, which are frequently comminuted and often compound. The break is most commonly situated a little above the middle of the shaft, the obliquity being downward, forward, and inward, and of such a nature that the fragments tend to override one another (Fig. 205).

The direction and nature of the displacement depends more upon the fracturing force, the weight of the lower part of the limb, and the action of the muscles attached to the respective fragments, than upon the direction of the obliquity. As a rule, the upper fragment is pulled forward and outward by the ilio-psoas and glutei muscles, while the lower fragment is displaced upward and inward, and is rotated outward by the combined action of the longitudinal muscles, the adductors, and the weight of the limb.

Clinical Features.—The limb is at once rendered useless, and there is great swelling from effusion of blood in the region of the fracture. This, together with the muscularity of the part, often renders an accurate diagnosis as to the site and direction of the fracture exceedingly difficult. The shortening varies from half an inch to three or four inches—averaging about one inch in adults—and eversion is always marked. Mobility may be detected and crepitus elicited without disturbing the patient, by placing the hand under the seat of fracture and gently attempting to raise the limb; or by fixing the upper fragment by one hand placed in front of it while the lower part of the limb is carefully lifted. It will be found

that the great trochanter does not rotate with the lower segment of the femur. These tests must be employed with great caution lest the deformity be increased or the fracture rendered compound.



FIG. 205.—Longitudinal section of Femur showing Recent Fracture of Shaft with over-riding of Fragments.

Treatment.—After reduction has been effected under an anæsthetic, extension strapping is applied from the ankle to a point well above the seat of the fracture; or, if the shortening persists, Steinmann's extension apparatus should be employed. The limb is then steadied between sand-bags and massage commenced. It is rarely necessary to enclose the thigh in a ferrule of Gooch splinting (Fig. 206), and a long splint can usually be dispensed with. The retentive apparatus should be worn for from six to eight weeks, after which the patient is allowed up with crutches, which he usually requires to use for three or four weeks longer, before he can bear his weight upon

the limb. The old dictum of Nélaton that the treatment of

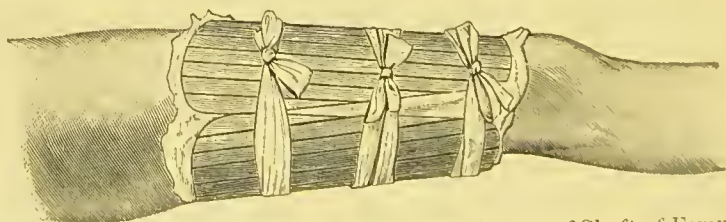


FIG. 206.—Local Gooch Splints applied for Fracture of Shaft of Femur. The splints should reach to the fold of the buttock.

fracture of the thigh should last for a hundred days is a safe working-rule. In fractures below the middle of the

shaft a Thomas' knee splint may be worn when the patient gets up.

Hodgen's splint is an efficient and comfortable means of treating this fracture.

In cases of oblique fracture, the patient should be warned that shortening to the extent of from three-quarters to one inch is liable to result, however carefully the treatment may be carried out. This does not necessarily imply a permanent limp, as by tilting the pelvis he may be enabled to walk quite well; if this is not sufficient to equalise the length of the limbs, the sole of the boot may be raised.

In many fractures of the thigh, and especially in those produced by indirect violence, the knee is sprained, and there is a considerable effusion into the joint, and this may lead to stiffness unless massage has been employed from the outset.

Union may be exceedingly slow in fracture of the femur, and may even be delayed for months. Mal-union sometimes occurs, the fracture uniting with an angular deformity outward and forward.

Re-fracture is very liable to occur if the patient falls or twists the limb within a few months of the original injury.

Operative treatment is sometimes called for when simpler measures fail to reduce the displacement, and in cases of un-united fracture or of vicious union. The incision, which must be free, is preferably placed in the line of the external

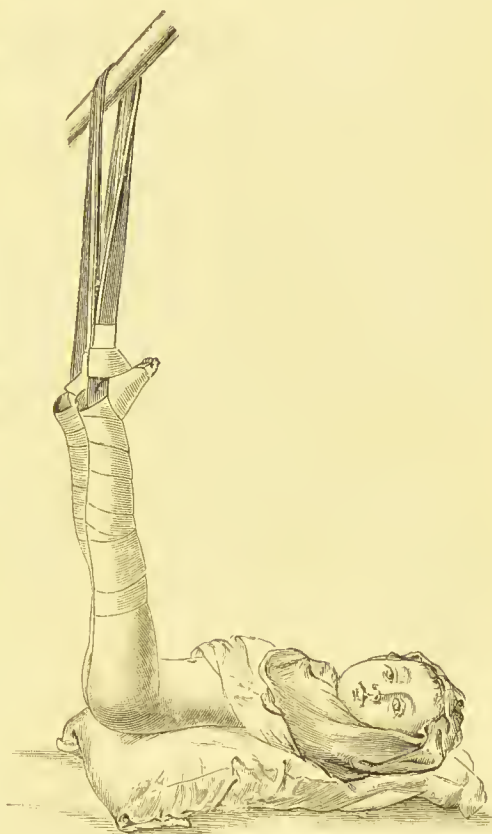


FIG. 207.—Fracture of Thigh treated by Vertical Extension.

intermuscular septum; the periosteum is interfered with as little as possible; and the ends of the bones are plated, pegged, or wired according to circumstances. The after-treatment is carried out on the same lines as for simple fracture, but the retentive apparatus must be worn for a considerably longer period.

Fracture of the Femur in Children.—In children, especially below the age of ten, this fracture is quite common. It is often of the greenstick variety, or, if complete, is transverse and subperiosteal, and as it is accompanied by few symptoms and but little deformity, is liable to be overlooked.

When there is displacement, the deformity is similar to that in adults, and the treatment is carried out on the same lines.

In young children the nursing is greatly facilitated by applying vertical extension to both lower extremities (Fig. 207). If the fracture is transverse and shows little tendency to displacement, the local Gooch splints may be dispensed with; in any case, massage should be employed from the first.

The patient may be allowed out of bed in from three to four weeks, wearing a retentive apparatus.

The shaft of the femur is sometimes fractured *during delivery*, particularly in breech cases. The simplest and most efficient means of controlling the fracture is by extension strapping fixed to the lower end of a Thomas' knee splint (Robert Jones).

CHAPTER XXVI

INJURIES IN THE REGION OF THE KNEE AND LEG

Surgical Anatomy—FRACTURES OF LOWER END OF FEMUR: *Supra-condylar*; *T- or Y-shaped*; *Separation of epiphysis*; *Either condyle*—FRACTURES OF UPPER END OF TIBIA: *Of head*; *Separation of epiphysis*; *Avulsion of tubercle of tibia*—DISLOCATIONS OF KNEE: *Dislocations of superior tibio-fibular joint*—INTERNAL DERANGEMENTS OF KNEE—INJURIES OF PATELLA: *Fractures*; *Dislocations*—INJURIES OF LEG: *Fracture of both bones*; *Fracture of tibia alone*; *Fracture of fibula alone*.

INJURIES IN THE REGION OF THE KNEE

THESE include the supra-condylar fracture of the femur, the T- or Y-shaped fracture opening into the joint, separation of the lower femoral epiphysis; fracture of the head of the tibia, and separation of its upper epiphysis; the various sprains and dislocations of the knee, as well as its internal derangements; and fractures and dislocations of the patella.

Surgical Anatomy.—Of the two condyles the internal is the more prominent and palpable. The adductor tubercle, which is situated on the upper and back part of the internal condyle, gives attachment to the round tendon of the adductor magnus, and marks the level of the epiphysial line and of the upper limit of the trochlear surface of the femur. Between the internal condyle and the inner tuberosity of the tibia, when the limb is in the flexed position, the line of the joint can be recognised as a groove or cleft, and this is made use of in measuring the length of the tibia. The outer tuberosity of the tibia can also be palpated, and must not be mistaken for the head of the fibula, which lies farther back and at a slightly lower level, and can readily be identified by tracing to it the tendon of the biceps. The tubercle of the tibia, into which the quadriceps extensor tendon is inserted, lies on the same level as the head of the fibula. In the extended position of the limb, the patella is loose and movable on the front of the trochlear surface of the femur, while in the flexed position it sinks between the condyles, resting chiefly on the outer one and becoming fixed.

The popliteal artery and vein and the internal popliteal nerve lie in

close relation to the posterior aspect of the joint; and the external popliteal nerve passes behind and to the inner side of the biceps tendon.

The knee is an example of a joint which depends for its strength chiefly on its ligaments. Not only are the external and internal lateral ligaments and the posterior part of the capsular ligament particularly strong, but the cruciate ligaments and the semilunar cartilages inside the cavity of the joint, further add to its stability. The powerful tendon of the quadriceps extensor muscle, in which the patella is developed as a sesamoid bone, protects and strengthens the front of the joint.

The synovial cavity extends from the level of the head of the tibia to an inch or more above the trochlear surface of the femur, passing

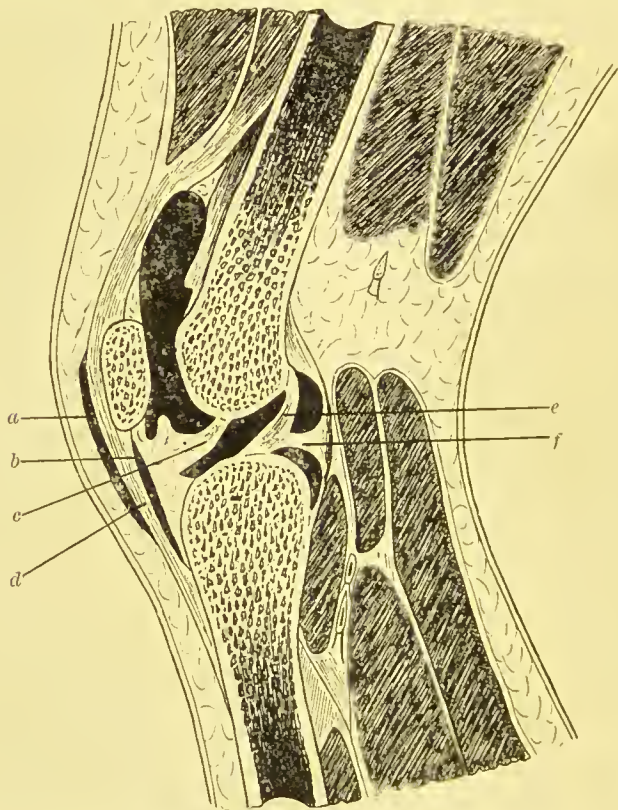


FIG. 208.—Section of Knee-Joint showing extent of Synovial Cavity.

a, Pre-patellar bursa. *b*, Infra-patellar bursa. *c*, Ligamentum mucosum. *d*, Ligamentum patellæ. *e*, Posterior crucial ligament. *f*, Internal semilunar cartilage.

(After Braune.)

slightly higher on the inner aspect of the joint than on the outer (Fig. 208). The large bursa between the quadriceps muscle and the femur (*sub-crural bursa*) generally communicates with the cavity of the joint. The synovial cavity of the superior tibio-fibular articulation is usually distinct from that of the knee-joint, but may communicate with it through the popliteal bursa.

A large bursa (*prepatellar*) lies over the lower part of the patella and upper part of the ligamentum patellæ; and a smaller one separates the ligamentum patellæ from the tubercle of the tibia. Several important bursæ are found in the popliteal space, one of which—the semi-membranosus bursa—sometimes communicates with the knee-joint.

FRACTURES OF THE LOWER END OF THE FEMUR

Fractures involving the lower end of the femur, especially the supra-condylar and T-shaped fractures, are always to be looked upon as serious injuries, on account of the difficulties attending their treatment, and the risk of impairment of the usefulness of the knee.

Supra-condylar fracture is usually the result of a fall on the feet or knees, or of direct violence, and is most common in adults. The line of fracture is generally irregularly transverse, or it may be slightly oblique from above downwards and forwards, so that the upper fragment passes forward towards the patella, while the lower is rotated backward on its transverse axis by the gastrocnemius muscle.

Clinical Features.—Soon after the accident a copious effusion of serum takes place into the cavity of the knee-joint, adding to the swelling caused by the displaced bones, and rendering it difficult to recognise the precise nature of the lesion. As it is important to make an accurate diagnosis, a general anæsthetic should be given when necessary for this purpose, and, if possible, the X-rays should be employed.

The upper end of the lower fragment is usually palpable in the popliteal space, while the upper fragment is unduly prominent in front. By flexing the knee the fragments may be brought into apposition and crepitus elicited. In oblique fractures, the pointed lower end of the upper fragment may transfix the quadriceps extensor muscle and may be felt under the skin, or it may perforate the skin and thus render the fracture compound. It should be disengaged by fully flexing and making traction on the knee. The thigh is shortened to the extent of from a half to one inch.

The popliteal vessels lie so close to the bone that they are liable to be torn by the displaced lower fragment, giving rise to the usual signs of ruptured artery. Sometimes, owing to the feeble state of the circulation from shock, the bleeding does not take place at the time of the accident, but ensues some hours later. The vessels may merely be pressed upon by the displaced bone, and the limb beyond become congested and

œdematous. There may also be injurious pressure on the nerves.

Treatment.—The small size of the lower fragment, its depth from the surface, and the accompanying effusion into and around the joint, render its control very difficult. In the majority of cases the two fragments can only be brought into apposition when the knee is flexed on the thigh and the thigh on the pelvis, and it is almost always necessary to carry out the reduction under anæsthesia.

In the few cases in which the fragments can be accurately approximated in the extended position of the limb, retention may be effected by means of a box-splint reaching well up the thigh (p. 608).

In the majority, however, flexion is necessary, and the limb must be fixed on a double-inclined plane, so constructed that the angle of flexion can be adjusted to meet the requirements of the individual case (Fig. 201). If extension is necessary, the difficulty may be got over by transfixing the condyles with steel pins, and attaching the apparatus directly to these (Steinmann).

Hodgen's splint, bent nearly to a right angle, is also found useful in the treatment of these injuries.

A careful watch must be kept on the circulation of the limb during the first few days, lest it be interfered with by the pressure of the apparatus.

In a considerable number of cases these means of retaining the fragments in apposition prove ineffectual, and it is necessary to have recourse to operative measures, mechanically securing the fragments by nails, screws, or wire sutures. Such operations entail opening the cavity of the joint, and should septic infection take place it may prove disastrous. Division of the tendo Achillis is not to be recommended as a means of combating the backward tilting of the lower fragment.

In all cases the retentive apparatus must be worn for about six or eight weeks, but massage and movement should be employed as soon as possible, as persistent stiffness of the knee is one of the most troublesome sequelæ of these injuries.

Compound and complicated fractures are dealt with on the general principles governing the treatment of such injuries. Amputation may become necessary should gangrene ensue from injury to the popliteal vessels, or if septic complications threaten the life of the patient.

Operative interference may be called for to rectify deformities resulting from mal-union.

The **T- or Y-shaped fracture** is, as a rule, produced by direct violence, the force first breaking the bone above the



FIG. 209.—Radiogram of Separation of Lower Epiphysis of Femur ; pressure on popliteal vessels caused sloughing of calf.

condyles, and then causing the upper fragment to penetrate the lower and split it up into two or more pieces. The fracture implicates the articular surface, and the main fissure is usually through the inter-condylar notch ; the lower end of the bone is sometimes severely comminuted.

The knee is broadened, and pain and crepitus are readily elicited on moving the condyles upon one another, or on pressing them together. On moving the patella transversely, it may be felt to hitch against the edge of one or other of the fragments. The shortening may amount to one or two inches.

The treatment is carried out on the same general lines as in supra-condylar fracture, but as the joint is implicated there is greater risk of subsequent impairment of its functions.



FIG. 210.—Fracture of Internal Condyle.

Separation of the lower epiphysis is a comparatively common injury. It is seldom pure, a portion of the diaphysis usually being broken off and remaining attached to the epiphysis. It occurs usually in boys between the ages of thirteen and eighteen, from severe violence such as results from the limb being caught between the spokes of a revolving wheel, or from hyper-extension of the knee. It has also been produced in attempting forcibly to rectify knock-knee and other deformities in this region, and in making traction on the limb to correct deformities following recovery from tuberculous disease of the knee. As a rule, there is little displacement of the loose epiphysis, but it may pass in any direction, forward being much the most common (Fig. 209), and when displaced it is difficult to reduce and to maintain in position.

The age of the patient, the mode of injury, the finding of the smooth broad end of the diaphysis in the popliteal space, or on the front of the thigh, according to the displacement, usually serve to establish the diagnosis. The X-rays afford reliable information as to the position of the fragments.

The treatment is the same as for supra-condylar fracture. After an epiphysial separation, the growth of the limb is sometimes, although not always, interfered with.

Either condyle may be broken off without the continuity of the shaft being interrupted, by a direct blow or fall on the knee, or by violent twisting of the leg. The separated condyle may not be displaced, or it may be pushed upwards or rotated on its transverse axis.

There is broadening of the knee but no shortening of the thigh, and the ecchymosis, crepitus, and pain are localised to the affected side of the joint. The knee can usually be moved towards the injured side in a way that is characteristic.

If there is difficulty in replacing the broken condyle and maintaining it in position, it may be fixed by means of a steel nail inserted through the skin.

FRACTURES OF THE UPPER END OF THE TIBIA

Fracture of the head of the tibia is a comparatively rare injury. It may result from a direct blow, such as the kick of a horse, or from indirect forms of violence, and the line of fracture may be transverse or oblique. Occasionally the lower fragment is impacted into the upper and comminutes it. Transverse fracture of the head of the fibula sometimes accompanies fracture of the head of the tibia, and there is always considerable effusion into the knee-joint. One or other of the tuberosities may be chipped off by forcible adduction or abduction at the knee.

The ordinary clinical features of fracture are well marked, and the diagnosis is easy. From some unexplained cause this fracture may take a very long time, sometimes several months, to consolidate.

Separation of the upper epiphysis of the tibia, which includes the tongue-like process for the tubercle and the facet for the fibula, is also rare (Fig. 211). It usually occurs between the ages of three and nine. The displacement of the epiphysis is almost always forward or lateral, and is accompanied by the usual signs of such lesions. The growth of the limb is sometimes arrested, and shortening and angular deformity may result (Fig. 213).

Treatment.—After reduction under an anæsthetic, these fractures are usually satisfactorily treated in a box-splint (Fig. 223),



FIG. 211.—Separation of Upper Epiphysis of Tibia in a boy æt. 15.

carried sufficiently high to control the knee-joint. When the head of the tibia is comminuted, light weight-extension—three or four pounds—should be used. Massage and movement are commenced from the outset, and at the end of a fortnight the patient is allowed up with crutches, wearing a moulded poroplastic splint.

Avulsion of the **tubercle of the tibia** occasionally occurs in youths, from violent contraction of the quadriceps—as in

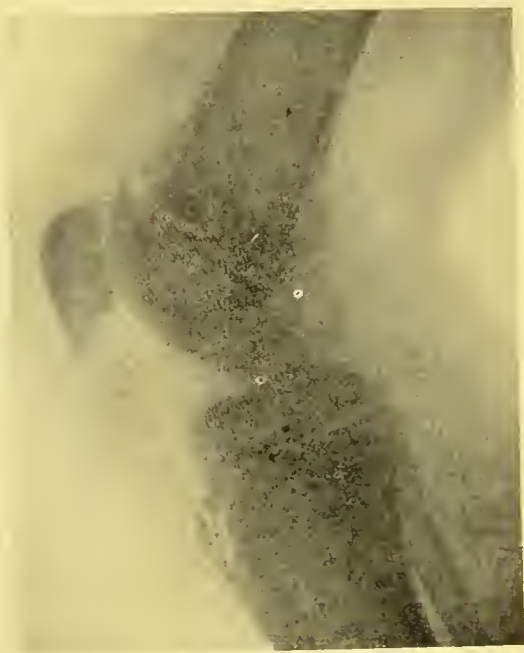


FIG. 212.—Radiogram illustrating Schlatter's disease.
(Mr. W. J. Stuart's case.)

jumping. The limb is at once rendered powerless; the osseous nodule can be felt, and on moving it crepitus is elicited.

This is best treated by pegging the tubercle in position, and fixing the extended limb on an inclined plane to relax the quadriceps muscle.

In young, athletic subjects, the tongue-like process of the epiphysis (Fig. 211), into which the ligamentum patellæ is inserted, may be partly or completely torn away, giving rise to localised swelling, and pain which is aggravated by any muscular effort—*Schlatter's disease* (Fig. 212). The treatment

consists in rest in bed and massage, but the symptoms are slow to disappear, and may persist for from six to twelve months.

The condition is liable to be mistaken for some chronic inflammatory condition of the bone, such as tubercle, unless an X-ray examination is made.

The **upper end of the fibula** is seldom broken alone. The



FIG. 213.—Separation and Displacement of Upper Epiphysis of Tibia of old standing.

chief clinical interest of this fracture lies in the fact that it may implicate the external popliteal nerve, and cause drop-foot.

DISLOCATIONS OF THE KNEE

Dislocation of the knee is a rare injury, and occurs as a result of extreme degrees of violence, especially of a wrenching or twisting character.

Rupture of the popliteal vessels, or pressure exerted on them by the displaced bones, may lead to gangrene of the limb, and

necessitate amputation. The external popliteal nerve is frequently damaged. When the lesion is compound, also, amputation may become necessary on account of septic complications.

The varieties of dislocation are named in terms of the direction in which the tibia passes: forward, backward, inward, and outward.

Dislocation forward is the most common variety, and results from sudden hyper-extension of the knee, tearing the lateral and crucial ligaments. The leg remains fully extended, and lies on a plane anterior to that of the thigh. The condyles are distinctly palpable posteriorly, and the skin is tightly stretched over them, or may even be torn, rendering the dislocation compound. The patella is projected forward, the quadriceps tendon is lax, and the skin over it is thrown into transverse folds. The limb is shortened by two or three inches.

Dislocation backward is usually due to a direct blow driving one of the bones past the other. The leg remains hyper-extended, the head of the tibia occupies the popliteal space, while the lower end of the femur projects forward with the patella either in front or to one side of it.

The **lateral dislocations** are generally incomplete, and are liable to be mistaken for separation of the lower epiphysis of the femur. When the tibia passes *inwards*, the outer condyle of the femur forms a prominence, and there is a depression below it. The head of the tibia projects on the inner side, and over the inner condyle is a depression.

When the tibia is displaced *outwards*, the relative position of the prominences and depressions is reversed.

Treatment.—In dislocations of the knee no special manipulations are necessary to restore the displaced bone to its place, and reduction is not accompanied by a distinct snap.

If, while the patient is fully anæsthetised, traction is made on the leg and counter-traction on the thigh with the knee in the flexed position, the bones can usually be replaced by manipulation.

After reduction has been effected, in antero-posterior dislocations, the limb should be flexed and placed on a pillow, massage and movement being employed from the first. The patient is usually able to walk about within a month.

In lateral dislocations there is at first considerable tendency to re-displacement, and it is therefore necessary to secure the joint in a box-splint, specially padded, for about fourteen days, massage being employed from the first, and movement com-

menced when the splint is removed. It is usually about six weeks before the patient can use the limb with freedom.

In compound dislocations, and in those complicated by injury to the popliteal vessels, the question of amputation may have to be considered.

Dislocation of the Superior Tibio-Fibular Articulation.—This joint may be dislocated by twisting forms of violence applied to the foot or leg, or by forcible contraction of the biceps muscle. The displacement may be forward or backward, and the head of the fibula can be felt in its new position with the prominent tendon of the biceps attached to it. The movements of the knee are quite free, but the patient is unable to walk on account of pain. Reduction and retention are, as a rule, easy, and the ultimate result satisfactory. We have frequently met with this injury accompanying compound fractures of both bones of the leg resulting from railway and similar accidents.

By applying direct pressure over the displaced bone with the knee flexed, the dislocation is easily reduced. It is kept in position by a firm bandage, or a light rigid splint.

Total Dislocation of Fibula.—Very rarely the fibula is separated from the tibia at both ends and displaced upwards. Bennett of Dublin has pointed out that in some persons the upper end of the fibula does not reach the facet on the tibia—a condition which might be mistaken for a dislocation.

INJURIES OF THE SEMILUNAR CARTILAGES

The semilunar cartilages are two crescentic plates of white fibro-cartilage, which lie upon the upper end of the tibia, and serve to deepen the articular surface for the condyles of the femur. Each cartilage is firmly attached to the tibia by its anterior and posterior ends, and, through the medium of the coronary ligaments, is loosely attached along its peripheral, convex edge to the head of the tibia, the internal cartilage being connected also to the capsular ligament of the joint. The tendon of the popliteus muscle intervenes between the external cartilage and the capsule. The central, concave edges of the cartilages are thin and unattached.

The cartilages enjoy a limited range of movement within the joint, passing backwards during flexion, and forwards again when the limb is extended. While the limb is partly flexed, a slight degree of rotation of the leg at the knee is

possible, and during this movement the cartilages glide from side to side, and the tibia rotates below the cartilages.

Any abnormal laxity of the ligaments of the joint may render the cartilages unduly mobile, so that they are liable to be displaced from comparatively slight causes, and when so displaced it is not uncommon for one or other of the cartilages to be torn by being nipped between the femur and the tibia. It is convenient to consider these "internal derangements of the knee-joint" separately, according to whether the cartilage is merely abnormally mobile, or is actually lacerated.

Mobile Cartilage—Displacement of Internal Semilunar Cartilage (Fig. 214).—The *internal* semilunar cartilage ex-

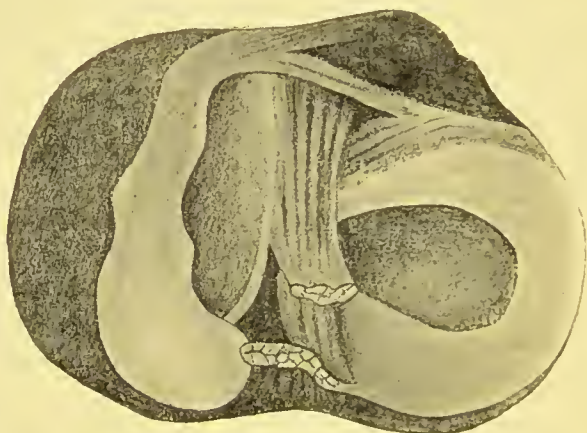


FIG. 214.—Diagram of Displacement of Right Internal Semilunar Cartilage towards the Centre of the Joint.

hibits undue mobility much more frequently than the external, and the condition is usually met with in adult males who engage much in athletics, or who follow an employment which entails working in a kneeling or squatting position for long periods, with the toes turned outwards—for example, coal-miners. The internal lateral ligament, and through it the coronary ligament, are thus gradually stretched, so that the cartilage becomes less securely anchored, and is rendered liable to be displaced towards the interior of the joint during some sudden movement which combines flexion of the knee with internal rotation of the femur upon the tibia, as, for example, in rising quickly from a squatting position, or turning rapidly and pushing off with the foot, in the course of some

game such as football or tennis. It may occur also from tripping on a loose stone or slipping off the kerbstone.

What actually happens when the cartilage is displaced would appear to be, that the combined flexion and abduction of the knee opens up the inner side of the joint by separating the internal condyle from the inner tuberosity of the tibia, and that the internal cartilage in its movement backward during flexion slips under the condyle and is caught between it and the tibia. It may even slip past the condyle and into the intercondyloid notch, and come to lie against the crucial ligaments.

The mechanism by which this lesion is produced doubtless explains the greater frequency with which the *left* knee is affected, as most sudden movements are made from right to left, thus throwing the strain upon the left knee.

Clinical Features.—When seen immediately after the accident, the patient will usually give the history that while making a sudden movement, he was seized with an intense sickening pain in the knee, accompanied, it may be, by a sensation of something giving way with a distinct crack, and followed by locking of the joint. He may fall to the ground and be unable to rise again. On examination, the knee is found to be fixed in a slightly flexed position; and while the surgeon may be able to carry out movements of flexion to a considerable extent without increasing the pain, any attempt to extend the joint completely is extremely painful. Tenderness may be elicited on making pressure to the inner side of the ligamentum patellæ in the groove between the femur and the tibia, but the cartilage cannot be recognised by palpation. Considerable effusion rapidly takes place into the synovial cavity.

The condition is liable to be mistaken for a sprain of the joint, particularly if the internal lateral ligament is implicated.

Treatment.—To reduce the displacement, the patient is placed on a couch, and, after the knee is fully flexed, the leg is rotated outward and abducted, to separate the internal condyle from the tibia, and while the rotation and abduction are maintained the leg is quickly extended. The return of the cartilage to its place is sometimes attended with a distinct snap, but in other cases reduction is only recognised to have taken place by the fact that the joint can be fully extended without causing pain.

Alternate flexion and extension combined with rotatory movements is sometimes successful. Several attempts are often necessary, and a general anaesthetic may be called for.

After reduction, the limb is fixed with sand-bags, and massage and movement are employed to get rid of effusion as rapidly as possible, great care being taken that no rotatory movement is permitted at the knee. Rest and support are necessary to allow of repair of the torn ligaments, and when the patient begins to use the joint he must be careful to avoid movements which throw strain on the ligaments that were damaged.

In a considerable proportion of cases so treated no recurrence takes place, and in the course of a month or two the patient is able to resume an active life with a perfectly useful joint. In other cases there is a tendency to recurrent displacement.

Recurrent Displacement.—In cases of recurrent displacement, each attack is accompanied by symptoms similar in kind to those above described, but less severe, and the patient usually learns to carry out some manipulation by which he is able to return the cartilage into position. He seeks advice with a view to having something done to prevent displacement occurring, and to restore the stability of the joint, which, in many cases, is impaired, preventing him following his occupation. There is reason to believe that a persistently mobile cartilage may be the starting-point of tuberculosis of the joint, or of arthritis deformans (Robert Jones, Arbuthnot Lane).

The symptoms closely resemble those of a pedunculated "loose body," and it is often difficult to differentiate between them. In the case of a body free in the cavity of the joint, the site of the pain may vary in different attacks, and the body can sometimes be palpated. Loose bodies wholly or partly composed of bone may be identified with the X-rays.

Attempts may be made to retain the cartilage in position by pads, bandages, or other forms of apparatus, so arranged as to prevent rotation and lateral movement at the knee. In the majority of cases, however, the best results are obtained by opening the joint and excising the cartilage in whole or in part, as may be necessary.

The limb is fixed on a splint until the wound has healed, after which massage should be employed and movement of the joint commenced. At the end of two or three weeks the patient is allowed up, wearing an elastic bandage. In most cases the use of the joint is completely regained in from four to six weeks.

Displacement of the external cartilage is comparatively rare. It is in every way comparable to displacement of the internal cartilage, and is treated on the same lines.

Torn or Lacerated Cartilage.—In a large proportion of

cases of displaced cartilage in which the condition assumes the recurrent type, it is found, on opening the joint, that, in addition to being unduly mobile, the cartilage is torn or lacerated. The experience of different surgeons varies regarding the nature of the laceration. In our experience the most common form is a longitudinal split, whereby a portion of the inner edge of the cartilage is separated from the rest and projects as a tag towards the cavity of the joint (Fig. 215). As a rule, it is the anterior end which is torn, less frequently the posterior end. Sometimes the cartilage is split from end to end, the outer crescent remaining in position, while the inner crescent passes in between the condyles and lies curled

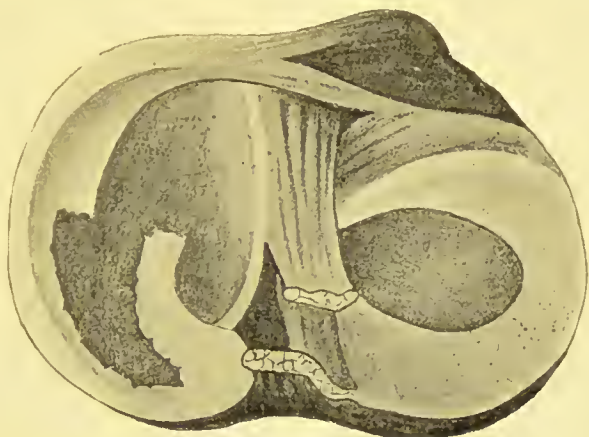


FIG. 215.—Diagram of Longitudinal Tear of Posterior End of Right Internal Semilunar Cartilage.

up against the crucial ligaments. Occasionally the anterior end is torn from its attachment to the tibia, less frequently the posterior end. In one case we found the cartilage separated at both ends and lying between the bones and the capsule.

The *clinical features* are similar to those of mobile cartilage with displacement, and as a rule the exact nature of the lesion is only discovered after opening the joint.

The *treatment* consists in excising the loose tag or the whole cartilage, according to circumstances. It is not advisable to attempt to stitch the torn portion in position.

Rupture of the Crucial Ligaments.—A few cases have been recorded in which, as a result of severe twisting forms of violence, the crucial ligaments have been torn from their attachments, leaving the joint loose and unstable, so that the

tibia and the femur could be moved laterally on one another. When the disability persists, the joint may be opened and the ligaments sutured in position (Mayo Robson).

Sprains of the knee are comparatively common as a result of sudden twisting or wrenching of the joint. In addition to the stretching or tearing of the ligaments, there is usually a considerable effusion of fluid into the synovial cavity, and examination with the X-rays occasionally reveals that a portion of bone has been torn away with the ligament—*sprain-fracture*. The swelling fills up the hollows on either side of the patella, and extends for some distance in the synovial pouch underneath the quadriceps. The patella is raised from the front of the femur by the collection of fluid in the joint—"floating patella"—and, if firmly pressed upon, it may be made to rap against the trochlear surface.

A sprain is to be diagnosed from separation of one or other of the adjacent epiphyses, fractures involving the articular ends of the bones, and displacement of the semilunar cartilages. On account of the swelling, which obscures the outline of the part, the differential diagnosis is often difficult, but as the swelling goes down under massage it becomes easier. Chief reliance is to be placed upon the bony points retaining their normal relationships, and upon the fact that the points of maximum tenderness are over the attachments of one or other of the lateral ligaments. As the internal lateral ligament suffers most frequently, the most tender spot is usually over its attachment to the inner aspect of the head of the tibia—less frequently over the internal condyle.

Unless efficiently treated, a sprain of the knee is liable to result in weakness and instability of the joint from stretching of the ligaments, and this is often associated with effusion of fluid in the synovial cavity (*traumatic hydrops*). This is more likely to occur if the joint is repeatedly subjected to slight degrees of violence, such as are liable to occur in football or other athletic exercises—hence the name "footballer's knee" sometimes applied to the condition.

Treatment.—In recent and severe cases the patient must be confined to bed, and firm pressure applied over the joint by means of cotton wool and a bandage. This may be removed once or twice a day to admit of the joint being douched with hot or cold water, and at the same time the joint should be massaged and moved to promote absorption of the effusion and prevent the formation of adhesions.

When there is chronic effusion into the joint, the best results

are obtained by rest and blistering. If the patient is unable to lie up, massage should be systematically employed, and a firm elastic bandage worn. A patient who has once had a severe sprain of the knee, or who has developed the condition of "footballer's knee," must give up violent forms of exercise which expose him to further injuries, otherwise the condition is liable to be aggravated and to result in permanent impairment of the stability of the joint.

INJURIES OF THE PATELLA

Fracture of the Patella is a comparatively common injury in adult males. Most frequently it is due to *muscular action*,



FIG. 216.—Radiogram of Fracture of Patella.

(Lent by Mr. George Hamilton of Liverpool.)

the patella being snapped across the lower end of the femur by a sudden and forcible contraction of the quadriceps extensor muscle while the limb is partly flexed—as, for example, in the attempt to avoid falling backward. The bone is then broken as one breaks a stick by bending it across the knee, and the line of fracture, which is transverse or slightly oblique, crosses

the bone a little below its middle. Fractures produced in this way are almost never compound.

The degree of displacement of the fragments depends upon the extent to which the lateral expansions of the quadriceps tendon are lacerated. As a rule, they are but slightly torn, so that the separation of the fragments does not exceed an inch. In other cases they are widely torn, and the contraction of the quadriceps muscle is then able to separate the fragments by three or four inches, and sometimes causes tilting of the upper fragment. The blood effused into the joint tends still further to increase the separation. As the periosteum is usually torn at a level lower than the fracture, its free margin hangs as a fringe from the upper fragment, and by getting between the broken ends may form a barrier to osseous union (Macewen).

Clinical Features.—Immediately the bone breaks, the patient falls, and he is unable to rise again, as the limb is at once rendered useless. The power of extending the limb is lost, and the patient is unable to lift his heel off the ground. The knee-joint is filled with blood and serous effusion, which usually extend into the bursa under the quadriceps. The two fragments can be detected, separated by an interval which admits of the finger being placed between them, and which is increased on flexing the knee. On relaxing the quadriceps, the fragments may be approximated more or less completely.

Prognosis.—In cases with little displacement, if the fragments have been kept in perfect apposition, osseous union may take place, but in the great majority of cases the union is fibrous. In certain cases the shortening of the quadriceps and the gradual stretching and thinning of the connecting fibrous band may allow of further separation of the fragments (Fig. 217), which to a variable extent interferes with the stability and functions of the limb. The upper fragment sometimes becomes attached to the front of the femur, and moves with it, and the fibrous band between the two fragments gradually becomes stretched. After bony union has occurred, it is not uncommon for the patella to be fractured again by a fall within a month or two of the original accident.

Treatment.—The best method of treating a fracture of the patella is still *sub judice*. It is probably true that the best functional results are most speedily obtained by operative measures. The laceration of the lateral aponeurosis, the tilting of the fragments, and the interposition of the torn periosteum between the fragments, can in no other way be rectified with

certainly. The operation, however, should only be undertaken by those who are familiar with wound technique, and who have every means at their disposal for carrying it out.

Non-operative Treatment.—In the majority of cases occurring in patients who do not follow a laborious occupation or otherwise lead an active life, a satisfactory result can be obtained without having recourse to operation. We have had reason to be satisfied with the following method: the patient is kept in bed for a few days, the injured region being supported on a pillow and massaged daily, and the patella moved from side to side as a whole to prevent adhesion to the femur. About the fourth day he is allowed to get about with crutches. As osseous union of the fragments is not essential to a good functional result, and as fibrous union does not necessarily entail any material interference with the usefulness of the limb, no attempt need be made to approximate the fragments, but every effort must be made to maintain the function of the quadriceps muscle and the mobility of the joint.

If it is desired to bring the fragments into contact and to secure osseous union, the limb should be placed upon an inclined plane to relax the quadriceps muscle, and means taken to arrest effusion and to diminish the swelling by systematic massage and a supporting bandage. When, in the course of a few days, this has been accomplished, the attempt is made to approximate the fragments, by fixing a large horseshoe-shaped piece of adhesive plaster to the front of the thigh, embracing the upper fragment. Extension is made upon this by means of rubber tubing, which is fixed to the foot-piece of the splint (Fig. 218). The bandage which binds the limb to the splint should make upward pressure on the lower fragment, or this may be done by a special piece of adhesive plaster with elastic tubing pulling in an upward direction.

The retentive apparatus is kept on for about three weeks, and a rigid, but easily removable, apparatus is thereafter

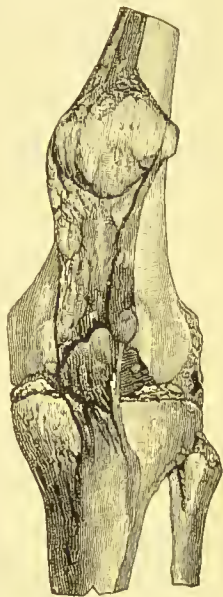


FIG. 217.—Fracture of Patella, showing wide separation of fragments, which are united by a fibrous band.

(Anatomical Museum of the University of Edinburgh.)

applied, and the patient allowed up on crutches, the limb being massaged and exercised daily to improve the tone of the muscles.

Operative treatment is specially indicated in young subjects who lead an active life, and in labouring men, particularly those who follow dangerous employments necessitating great stability of the knees.

As soon as the wound is healed,—in a week or ten days,—massage and movement of the limb are commenced, and the patient is encouraged to move his limb in bed. At the end of another week he may be allowed up with sticks or crutches.

When the fracture is caused by *direct violence*, such as a fall on the knee or the kick of a horse, it may be transverse, oblique, or vertical, but in many cases it is stellate, the bone

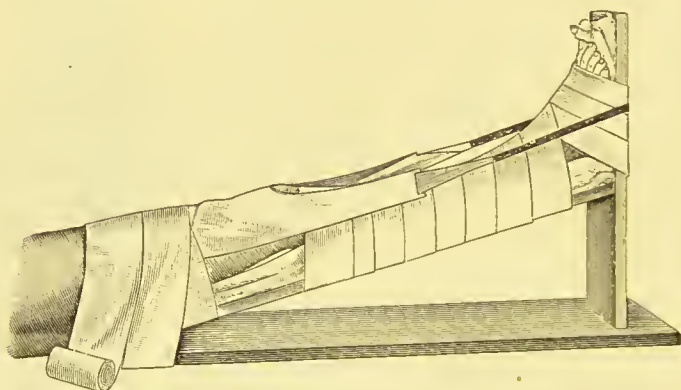


FIG. 218.—Treatment of Fracture of Patella by means of Inclined Plane and Elastic Extension.

being broken into several irregular pieces. These comminuted fractures are frequently compound. In transverse and oblique fractures, the displacement depends upon the same causes as in fracture by muscular action. In vertical and stellate fractures, unless the knee has been forcibly flexed after the bone has been broken, there is little or no displacement. The treatment is governed by the same considerations as in fractures by muscular action.

Old-standing Fractures.—As fibrous union, even with an interval of several inches between the fragments, is not incompatible with a useful limb (Fig. 219), it is not often necessary to operate for this condition, but when the usefulness of the limb is seriously impaired, operative treatment is

indicated. The operation is carried out on the same lines as for recent fracture, the ends of the bones being rawed and adhesions divided. When the upper fragment has become attached to the femur, it should be separated, and it is sometimes necessary to lengthen the quadriceps muscle by making a number of V-shaped incisions through its substance, before the fragments can be approximated; or a flap may be turned down from the rectus and stitched to the patella and the ligamentum patellæ.



FIG. 219.—Old-standing Fracture of Patella with wide separation of fragments.

(The patient was able to follow his occupation as a dock-labourer.)

When operative treatment is contra-indicated, the patient should be fitted with a firm apparatus which will limit flexion of the knee and support the fragments.

Dislocations of the patella are rare. They result from exaggerated muscular movements when the limb is in the fully extended position, or from a blow on one or other edge of the bone. Laxity of the ligaments and knock-knee are predisposing factors. They are sometimes associated with fracture of the edge of the trochlear surface, which renders retention in position difficult.

The *outward* is the most common variety—the *inward* being

rare. Either may be complete or incomplete. Sometimes the bone is rotated so that its edge rests on the front of the femur—*vertical* dislocation (Fig. 220); and in a few cases it has been completely turned round, so that the articular surface was directed forwards.

Clinical Features.—The joint is fixed, usually in a position of slight flexion, and the displaced patella can readily be palpated. The deformity is a very striking one, and at first sight suggests a much more serious injury. Although easily reduced, the dislocation is liable to recur.

To effect reduction, the quadriceps must be thoroughly relaxed by extending the leg upon the thigh and flexing the thigh upon the pelvis, the patella is then tilted by making firm



FIG. 220.—Vertical Dislocation of Patella.

pressure on that edge which lies farthest from the middle of the joint, and at the same time pushing towards the middle line. The limb is placed on a posterior splint, and firm elastic pressure made on the joint to prevent or diminish effusion. Massage and movement are carried out from the first.

As the displacement is liable to recur, the patient should wear a firm elastic bandage or a strong knee-cap.

Permanent and recurrent dislocations of the patella will be described in the chapter on Deformities.

FRACTURES OF THE BONES OF THE LEG

The bones of the leg may be broken together or separately.

Fracture of both Bones.—The features of this injury depend to a large extent upon the nature of the violence producing it. In fracture by *direct* violence, such as the passage of a wheel over the limb or a severe blow, the bones give way at the point of impact, and the line of fracture tends to be transverse, both bones being broken at the same level (Fig. 221).

There is often little or no displacement, and such as there is is angular, and is determined by the direction of the fracturing force.

When the violence is *indirect*, as from a fall on the feet, or a twist of the leg, the tibia usually gives way at the junction of



FIG. 221.—Radiogram of Transverse Fracture of both Bones of Leg by direct violence.



FIG. 222.—Radiogram of Oblique Fracture of both Bones of Leg by indirect violence.

its lower and middle thirds, and the fibula at a higher level (Fig. 222). Torsion of the tibia is probably the most important factor in the production of the fracture, the lower fragment being fixed by the pressure of the foot upon the ground, while the upper fragment is rotated by the impetus of the body. Both fractures are usually oblique—that in the tibia running from above downward, forward, and inward, and it is generally found

that the obliquity of the fibular fracture corresponds with that in the tibia.

There is usually considerable displacement, the weight of the lower portion of the limb causing it to fall backwards and to roll outwards, and the traction of the calf muscles pulling up the heel and pointing the toes. The upper fragments form a projection on the front of the limb.

On account of the superficial position of the tibia and the pointed character of the fragments, this fracture is frequently rendered compound by the bone being forced through the skin. The projecting piece of bone is usually the lower end of the upper fragment. This fracture is often comminuted. It has been observed that when the line of fracture forms the letter V on the subcutaneous surface of the tibia, there is invariably a fissure passing down along the back of the bone into the ankle-joint—a complication which adds to the risk of subsequent stiffness and impaired usefulness of the limb. Apart from this, the ankle is usually sprained in fractures by indirect violence, and we have frequently found the superior tibio-fibular articulation torn open in severe fractures of both bones of the leg.

Clinical Features.—The tibial fracture is readily recognised by detecting an irregularity on running the fingers along the crest of the shin, and at this point abnormal mobility, tenderness, and crepitus can usually be elicited. It is often difficult to detect the fibular fracture, and it is not always advisable to attempt to do so, especially if the necessary manipulations cause pain or tend to increase the displacement. The condition of the fibula is usually to be inferred by noting the amount of deformity and the extent of mobility of the tibial fragments. Not infrequently the seat of fracture may be recognised by locating a point at which pain is elicited on making pressure over the bone at a distance—pain on distal pressure.

On account of the close connection of the skin to the periosteum on the subcutaneous aspect of the tibia, the tension caused by extravasated blood is often extreme; blisters frequently form over the area of ecchymosis, and when these become infected, sloughing of the skin may take place and the fracture thus be rendered compound.

The vessels and nerves of the leg are seldom seriously damaged.

Treatment.—If there is marked displacement, reduction is most satisfactorily accomplished under anaesthesia. Traction

is made upon the foot and the fragments are manipulated into position, the pointing of the toes and the outward rotation of the foot being at the same time corrected. The normal outline of the foot in relation to the leg is restored when the ball of the great toe, the internal malleolus, and the inner edge of the patella are in the same vertical plane. As in other fractures of the lower extremity, the limb should be placed in the natural position of slight eversion: not with the toes pointing straight forward.

The retentive apparatus to be applied depends upon the tendency to re-displacement, the degree of swelling, and the extent of the damage to the skin.

In the average case, the leg is supported between sand-bags, and massage and movements are employed from the outset. When massage is not obtainable, the limb may be immediately enclosed in a rigid apparatus, such as lateral poroplastic splints retained in position by an elastic bandage, or a Croft's splint, which can readily be removed to admit of massage. When the fracture is in the lower third of the leg, the ambulatory splint gives excellent results, and is of special service in hospital practice (Fig. 227).

When the fracture is oblique and it is difficult to retain the fragments in position, or when there is great swelling with blisters or bruises on the skin, a splint which admits of easy access to the limb is to be preferred. One of the simplest and most efficient is the box splint (Fig. 223). This consists of two pieces of wood extending from above the knee to an inch or two beyond the sole, and a little broader than the maximum diameter of the leg. These are rolled into the opposite ends of a folded sheet, so as to form two sides of a box, of which the sheet constitutes a third side. It is found advantageous to insert another board, fitted with a foot-piece, between the folds of the sheet forming the third side of the box, to add to the rigidity of the splint, and to aid in controlling the foot. By folding one side of the sheet somewhat obliquely, the box is made a little wider at the knee than at the ankle, and so fits the limb more accurately.

The limb is placed in this box, the sides of which have been carefully padded. Ring pads are applied to take pressure off the condyles, the head of the fibula, the malleoli, and the tip of the heel, and a large supporting pad is placed behind the tendo Achillis. A folded towel is laid over the front of the leg, forming a lid to the box, and the whole is bound to the limb by three slip-knots. Finally, the foot is fixed at right angles to

the leg and slightly abducted, by a figure-of-eight bandage or a piece of elastic webbing. Sand-bags placed alongside serve to steady the limb. In fractures in the lower third of the leg, the box splint may stop short of the knee, and the limb may then be suspended in a Salter's cradle, which allows the patient to move about more freely in bed.

To prevent shortening in oblique fractures and in those

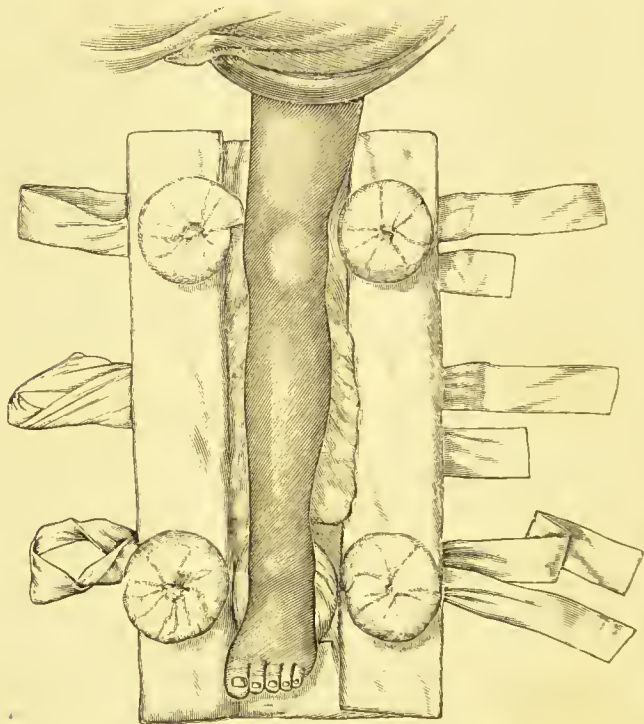


FIG. 223.—Box Splint for Fractures of Bones of Leg.

near the ankle-joint, where it is often difficult to control the lower fragment, extension, applied by weight and pulley, may be of service. The strapping may be applied only to the lower fragment, but we prefer to carry it to the upper third of the leg. If the over-riding of the fragments persists, Steinmann's extension apparatus is used, the pins being driven through the malleoli.

When the skin is damaged, as it so frequently is on the inner aspect of the tibia, means must be taken to prevent septic infection.

Massage is carried out daily as soon as the condition of the skin will admit of it, and, to prevent stiffness, the ankle is moved from the first. In the course of three weeks, lateral poroplastie splints retained by an elastic bandage may be substituted, and the patient allowed up on crutches. In simple fractures without displacement, union is usually complete in from six to eight weeks, but when the fracture is oblique, comminuted, or compound, union is often delayed, and the functions of the limb may not be fully regained for three or even four months after the accident.

Operative Treatment.—When overriding cannot otherwise be corrected, it is advisable to secure the fragments mechanically by operation. A curved incision with its convexity backward is made over the inner side of the tibia, exposing the fragments, which are then screwed, plated, or wired according to circumstances. It is seldom necessary to deal specially with the fibula. A box splint is applied till the wound has healed, after which a poroplastie splint is substituted and massage commenced.

We do not share in the dissatisfaction expressed by some surgeons, notably Arbuthnot Lane, as to the results obtained by non-operative means in the common fractures of the leg, and do not recommend a systematic resort to operative treatment.

Un-united fracture of the bones of the leg is sometimes met with. It is treated on the same lines as in other situations, but may prove extremely intractable, especially in the case of children, in whom, indeed, it is sometimes incurable.

Mal-union (Fig. 224), on account of the disability it entails, may call for operative treatment in the form of osteotomy of one or both bones.

Compound fractures of the leg are very common, and are treated on the lines already laid down for the treatment of compound fractures in general (p. 450).



FIG. 224.—A Badly-united Fracture of both Bones of Leg, occurring in a lad who had had no treatment.

Fracture of the tibia alone, when due to direct violence, is usually transverse, there is little displacement, and as the intact fibula retains the fragments in position, union takes place rapidly and without deformity. Oblique and spiral fractures result from indirect violence, and are extremely rare.

Fracture of the fibula alone may result from direct violence, and, on account of the support given by the tibia, is usually unattended by displacement or deformity. Bennett of Dublin has pointed out that it is common to meet with an oblique fracture of the upper third of the fibula as the result of an outward twist of the ankle while the foot is extended. It is characterised by pain localised at the seat of the break, on moving the foot in such a way as to bring the astragalus to bear against the fibula. Local pressure also may make the fibula yield and may elicit crepitus. In some cases this fracture is associated with injuries in the region of the ankle-joint. It is often overlooked, and from want of proper treatment may result in prolonged impairment of usefulness of the limb.

Fractures of the tibia or fibula alone are treated on the same lines as fractures of both bones. The ambulant method is particularly useful in these cases (Fig. 227).

CHAPTER XXVII

INJURIES IN REGION OF ANKLE AND FOOT

Surgical anatomy.—FRACTURES: *Pott's fracture*; *Converse of Pott's fracture*; *Separation of lower epiphysis*; *Fracture of astragalus*; *Fracture of os calcis*; *Fractures of other tarsal bones*; *Fractures of metatarsal bones*; *Fractures of phalanges*—DISLOCATIONS: *Of ankle-joint*; *Of inferior tibio-fibular joint*; *Complete dislocation of astragalus*; *Sub-astragaloid dislocation*; *Medio-tarsal dislocation*; *Tarso-metatarsal dislocation*; *Dislocations of toes*.

THE fractures in this region include Pott's fracture, and its converse; separation of the lower epiphysis of the tibia; fractures of the astragalus, os calcis, and other tarsal bones; and fractures of the metatarsals and phalanges. Various dislocations also occur, the most important being those of the ankle-joint, of the astragalus, and the sub-astragaloid dislocation.

Surgical Anatomy.—For the study of injuries in the region of the ankle-joint it is of importance to define the terms employed in describing the movements of the foot. Thus by *flexion* or *dorsiflexion* is meant that movement which approximates the dorsum of the foot to the front of the leg; while *extension* or *plantar flexion* means the drawing up of the heel so that the toes are pointed. In *inversion* the inner edge of the foot is drawn up so that the sole looks inwards, an attitude which is analogous to supination of the hand. In *eversion* the outer edge of the foot is drawn up, the sole looking outwards—analogueous to pronation of the hand. *Adduction* indicates the rotation of the foot so that the toes are turned towards the middle line of the body; while in *abduction* the toes are turned away from the middle line.

The most prominent bony landmarks in the region of the ankle are the two *malleoli*, the external lying slightly farther back, and about half an inch lower than the internal. On the inner side of the foot from behind forward may be felt the *internal tuberosity* of the os calcis; the *sustentaculum tali*, which lies about one inch vertically below the tip of the malleolus; the *tubercle of the scaphoid*, about an inch in front of the malleolus, and at a slightly lower level; the *internal cuneiform*, and the base, shaft, and head of the *first metatarsal*.

On the outer side may be recognised the *external tuberosity* of the os calcis, the *peroneal tubercle* on the same bone; the *cuboid*; and the prominent base of the *fifth metatarsal*.

The astragalo-scaphoid joint lies immediately behind the tubercle of the scaphoid, and a line drawn straight across the foot at this level passes over the calcaneo-cuboid joint.

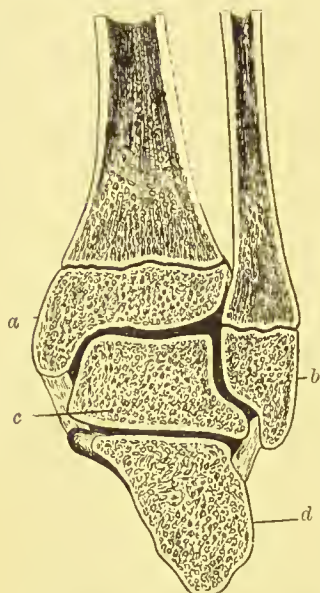


FIG. 225.—Section through Ankle-Joint showing relation of epiphyses to synovial cavity.

- a, Lower epiphysis of tibia.
- b, Lower epiphysis of fibula.
- c, Astragalus.
- d, Os calcis.

(After Poland.)

The *ankle-joint*, formed by the articulation of the tibia and fibula with the astragalus, lies about half an inch above the tip of the internal malleolus, and is so constructed that when the foot is at a right angle with the leg it is only possible to flex and extend the joint. When the toes are pointed, however, slight lateral and rotatory movements are possible. The chief seat of lateral movement of the foot is at the astragalo-scaphoid and calcaneo-cuboid articulations—"the mid-tarsal or Chopart's joint."

The ankle-joint owes its strength chiefly to the malleoli and the lateral ligaments, and to the inferior tibio-fibular ligaments, which bind together the lower ends of the bones of the leg. The numerous tendons passing over the joint on every side also add to its stability.

The synovial membrane of the ankle-joint passes up between the bones of the leg to line the inferior tibio-fibular joint; but it is distinct from that of the inter-tarsal joints, which communicate with one another in a complicated manner. The epiphyseal cartilage at the lower end of the fibula lies on the level of the astragalo-

tibial articulation, while that of the tibia is about half an inch higher (Fig. 221).

FRACTURES IN THE REGION OF THE ANKLE

Pott's Fracture.—It must clearly be understood that various lesions occurring in the region of the ankle-joint are included under the clinical term "Pott's fracture." Although of a similar nature, and produced by the same forms of violence, these vary considerably in their anatomy and clinical features. They are all the result of *combined eversion and abduction* of the foot—produced, for example, by slipping off the kerbstone, or by the patient jumping from a height and landing on the inner side of the foot.

When forcible *eversion* is the chief movement, the tightening of the internal lateral ligament usually tears off the internal malleolus across its base. The astragalus is then brought to

bear on the external malleolus, and the force continuing to act, the lower end of the fibula is pressed outwards, and breaks close above the malleolus. The inferior tibio-fibular ligament may rupture, or the outer portion of the tibia, to which it is attached, may be avulsed. This form is sometimes called *Dupuytren's fracture*. When the bones are widely separated in Dupuytren's fracture the astragalus may be forced up between them.

When the movement of *abduction* predominates, the internal lateral ligament is usually ruptured, or the anterior edge or tip of the internal malleolus torn off. The inferior tibio-fibular ligament usually resists, and an oblique fracture of the fibula two or four inches above its lower end results.

Clinical Features.—In a considerable proportion of cases—in our experience in the majority—this fracture is not accompanied by any marked deformity of the foot, and the patient is often able to walk after the injury with only a slight limp.

In others, however, the deformity is marked and characteristic (Fig. 226). The foot is everted, its inner side resting on the ground. The internal malleolus is unduly prominent, stretching the skin, which may give way if the patient attempts to walk. The foot having lost the support of the malleoli, is often displaced backward, and the toes are pointed by the contraction of the calf muscles. There is abnormal mobility—both lateral and antero-posterior—and crepitus may be elicited. The points of tenderness are over the internal lateral ligament or internal malleolus, the inferior tibio-fibular joint, and at the seat of fracture of the fibula. Distal pressure over the shaft of the fibula, or on the extreme tip of the malleolus, may elicit pain and crepitus at the seat of fracture. There is usually considerable ecchymosis

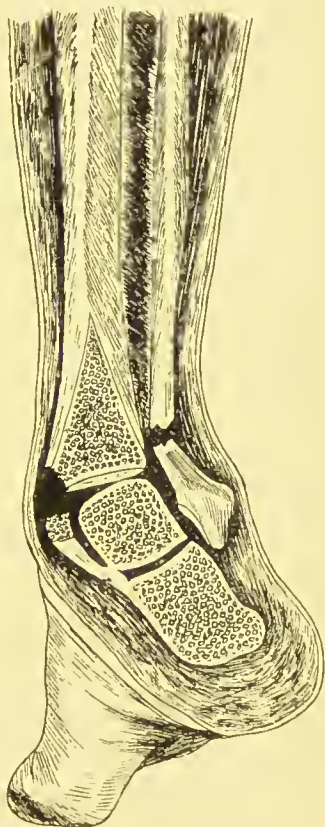


FIG. 226.—Diagram of Pott's Fracture from behind.
(After Helferich.)

and swelling in the hollows below and behind the malleoli; and the malleoli appear to be nearer the level of the sole. In Dupuytren's fracture, when the astragalus passes up between the tibia and fibula, there is great broadening of the ankle.

There is often considerable difficulty in distinguishing a *sprain* of the ankle from a fracture without displacement, as both forms of injury result from the same kinds of violence, and are rapidly followed by swelling and discoloration of the overlying soft parts. In a sprain, the point of maximum tenderness is



FIG. 227.—Ambulant Splint of Plaster of Paris.

over the ligaments and tendon sheaths that have been damaged, while in fracture the site of the break is the most tender spot. The X-rays are often useful in the diagnosis of doubtful cases.

Treatment.—In those cases of fracture of the lower end of the fibula in which there is no marked displacement,—and they constitute a considerable proportion,—the limb should be massaged and laid on a pillow between sand-bags, or placed in a box splint for two or three days, until the swelling subsides. Some form of rigid apparatus, such as lateral poroplastic splints fixed in position with an elastic bandage, which will allow the patient to get about with crutches, is then applied. This is removed daily to permit of massage and movement being carried

out—a point of great practical importance, because if this is neglected, not only does union take place more slowly, but the stiffness of the ankle and œdema of the leg and foot which ensue, prolong the period of the patient's incapacity and endanger the functional usefulness of the limb.

It is in cases of this kind that the *ambulatory method* of treatment yields its best results.

When, in the course of two or three days, the swelling has subsided, a plaster-of-Paris case (Fig. 227) is applied in such a way that when the patient walks the weight is transmitted from the tuberosities of the tibia through the plaster case to the ground, no weight being borne by the bones at the seat of fracture. The

apparatus is applied as follows:

A boracic lint bandage is applied to the limb as far as the knee, and protecting pads or rings of wool are placed over the tuberosities of the tibia, the head of the fibula, and the malleoli. A pad of wool about three inches thick is then placed under the sole and fixed in position by a plaster-of-Paris bandage, which is carried up the limb in the usual way. The case is made specially strong on the sole, around the ankle, up the sides of the leg, and at the bearing-point at the head of the tibia.

After the plaster has thoroughly set, the patient is allowed to walk about with a stick, crutches being unnecessary. In the course

of three weeks the plaster case may be removed and the limb massaged. It is usually found that the movements of the ankle are scarcely interfered with, and the patient is generally able to resume work within a month of the accident.

When there is marked eversion of the foot, it is sometimes necessary to administer a general anæsthetic to reduce the deformity; and to prevent recurrence of the displacement

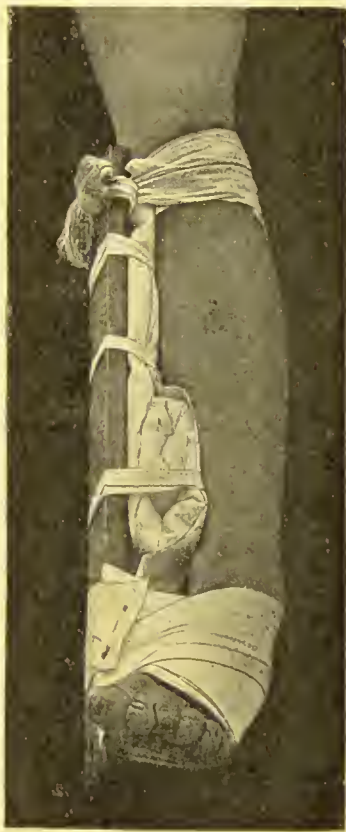


FIG. 228.—Dupuytren's Splint applied to correct Eversion of Foot.

Dupuytren's splint (Fig. 228) may be used. This splint, which is of the same shape as Liston's long splint, but on a small scale, is applied to the inner side of the leg, extending from just below the knee to well beyond the sole of the foot. A large pad is placed in the hollow above the internal malleolus, and it must be thick enough to carry the splint so far from the limb that when the foot is fully inverted it does not touch the splint. The upper end of the splint having been fixed to the leg at the level of the tuberosities of the tibia, a bandage is applied to correct the eversion of the foot, and at the same time to support the heel, and, as far as possible, to overcome the pointing of the toes. Care must be taken to avoid carrying the turns of this bandage over the seat of fracture. The limb

may then be slung in a cradle, or placed on a pillow resting on its outer side with the knee flexed. In the course of a few days, a poroplastic or a Croft's splint may be substituted and massage commenced.

When backward displacement of the heel is the prominent deformity, *Syme's horse-shoe or stirrup splint* (Fig. 229) is

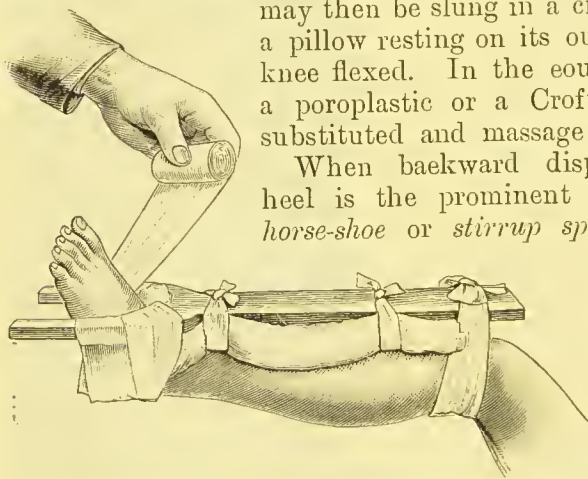


FIG. 229.—Syme's Horse-shoe Splint applied to correct backward displacement of foot.

sometimes employed. It is applied to the anterior aspect of the limb, which is carefully padded to prevent undue pressure on the edge of the shin bone.

As the inner aspect of the leg slopes from the crest of the shin more abruptly than the outer, in order that the splint may have a flat surface to rest upon, the padding must be twice as thick on the inner as on the outer side. After the upper end of the splint has been fixed below the knee, the heel is pulled forward by a few turns of bandage passed over the prongs at the lower end of the splint. The foot is then inverted and brought up to a right angle by a few supplementary turns of the bandage. In a few days this appliance may be replaced by a poroplastic or a Croft's splint. In cases with marked displacement or with displacement controlled with difficulty by ordinary means, recourse may be had to plating the fibular fragments by open operation.

Mal-union of Pott's fracture may necessitate an operation to restore the usefulness of the ankle. The bone is divided by means of an osteotome, the foot forcibly inverted, and the limb put up in the same way as in a recent fracture.

The Converse of Pott's Fracture — sometimes called "**Pott's Fracture with Inversion.**"—This injury is fairly common, and results from forcible inversion of the foot. The external malleolus is broken across its base, or, in young subjects, along the epiphysial line. The internal malleolus alone may be carried away, or a portion of the broad part of the tibia may accompany it.

The foot is inverted, the heel falls back, and the toes are pointed (Fig. 230). In other respects it corresponds to the typical Pott's fracture, and is treated on the same principles. When Dupuytren's splint is required, it is, of course, applied to the outer side of the leg.

Separation of the lower epiphysis of the tibia is not very common. It occurs most frequently between the ages of eleven and eighteen as a result of forcible eversion or inversion of the foot. It is usually accompanied by fracture of the diaphysis of the fibula, and is not infrequently compound. When the epiphysis is displaced laterally, the deformity is characteristic. In rare cases the growth of the tibia is arrested, the continued growth of the fibula causing the foot to become inverted. The treatment is the same as for Pott's fracture.

Fracture of the astragalus usually occurs as a result of a fall from a height, the bone being crushed between the tibia and the os calcis. It is usually associated with other fractures, and is sometimes impacted, the foot assuming the position of equino-varus. The diagnosis is only to be made by exclusion, or by the use of the Röntgen rays. In uncomplicated cases, the treatment consists in immobilising the foot and leg in a poroplastic splint and applying massage. In comminuted and in impacted fractures with persistent deformity, complete excision of the bone yields good results. In interpreting radiograms of injuries



FIG. 230. — Converse of Pott's Fracture. Man æt. 37. Blow on outer side of ankle. Tibia broken about two inches above tip of internal malleolus. Tip of external malleolus chipped off.

in this region, care must be taken not to mistake the *os trigonum tarsi* for a fracture.

The **os calcis** is most frequently broken by the patient falling from a height, and landing on the sole of the foot, and the injury may occur simultaneously in both feet.

The primary fracture is usually longitudinal, passing through the facets for the astragalus and cuboid, and from this various secondary fissures radiate; the cancellated tissue is much crushed, so that the whole bone is flattened out. In spite of the great comminution, it is often impossible to elicit crepitus, as the fragments are held together by the investing soft parts. In other cases the foot may feel like "a bag of bones." The lesion is often mistaken for a fracture of the lower end of the fibula, or is not diagnosed at all. The chief clinical feature is pain on movement of the foot, or on attempting to walk; the foot appears flat, and the hollows on either side of the tendo Achillis are filled up. In many cases there is a persistent tenderness which delays restoration of function for some months, but the ultimate result is usually satisfactory.

Treatment.—In simple comminuted fractures the patient should be anæsthetised, and the foot moulded into position, special care being taken to restore the arch in order to avoid any tendency to flat foot. The foot is supported on a pillow, and to prevent stiffness, massage and movements of the ankle and tarsal joints should be commenced without delay.

Compound fractures confined to the *os calcis* may be treated on conservative lines, but if associated with other injuries of the foot they may necessitate amputation.

The *posterior tubercle of the os calcis*, into which the tendo Achillis is inserted, is sometimes separated by forcible contraction of the calf muscles, or from a fall on the ball of the foot. The separated fragment may be pulled up for a distance of one or two inches, and the rough surface from which it has been torn may be recognisable. The patient may be able to walk immediately after the accident, although with difficulty; or he may have persistent pain for many months.

A good functional result is usually obtained by relaxing the calf muscles and fixing the foot in the position of extreme plantar flexion with the knee flexed, but in some cases it is advisable to peg the fragments, either through the skin or after exposing them by operation.

The **other bones of the tarsus** are rarely fractured separately. The *tubercle of the scaphoid* is sometimes torn away by violent traction on the ligaments attached to it.

Fractures of the metatarsals and phalanges usually result from direct violence, such as a crush of the foot, in which the soft parts are severely damaged. The use of the Röntgen rays has shown, however, that certain painful conditions in the foot following comparatively slight injuries, such as kicking a stone, are due to a fracture of one of the metatarsals or phalanges.

When simple, these injuries are often overlooked, on account of the difficulty of eliciting the signs of fracture from the swelling which accompanies them. They are best treated in a rigid moulded splint.

Compound fractures are more common, and are to be treated on the same principles as govern such injuries elsewhere.

A *fracture of the base of the fifth metatarsal* has been described by Robert Jones of Liverpool. It is produced by the patient coming down forcibly on the outer edge of the foot while the foot is inverted and the heel raised—as, for example, in dancing. There is a localised swelling over the base of the fifth metatarsal, and pain when the patient puts weight on the foot. There is no crepitus or deformity. The fracture is readily recognised by the Röntgen rays. Massage and movement are employed from the first.

DISLOCATIONS IN THE REGION OF THE ANKLE

Dislocations of the Ankle-Joint.—In describing dislocations of the astragalus from the tibio-fibular socket, the varieties are named according to the direction in which the foot passes—backward, forward, inward, outward, or upward.

All of them may be complete, but they are more frequently incomplete, and are liable to be rendered compound, either from tearing of the skin at the time of the injury, or by its sloughing later. Although as a rule there is little difficulty in effecting reduction by manipulation, these injuries are liable to be followed by stiffness and impaired usefulness of the joint.

The *backward* dislocation is the most common, and results from extreme plantar flexion of the foot, as from a fall backwards while the foot is fixed, wedging the astragalus between the tibia and fibula. The lateral ligaments are torn, and one or both malleoli may be broken, or the posterior part of the articular edge of the tibia chipped off.

The foot appears shortened, the heel is unduly prominent behind, and the lower ends of the tibia and fibula project in

front, sometimes coming through the skin. The tendons around the joint are stretched or torn.

Forward dislocation results from extreme dorsal flexion at the ankle-joint. The foot appears lengthened, the heel is



FIG. 231.—Radiogram of Backward Dislocation of Ankle.

(Professor Chiene's case.)

less prominent than normal, and the hollows on each side of the tendo Achillis are obliterated. The astragalus is felt in front of the tibia, and the malleoli appear to be displaced backwards and to lie nearer the sole.

Lateral dislocations—inward or outward—are only possible

after fracture of one or both malleoli, and may be looked upon as complications of these injuries (Fig. 231).

In cases in which the interosseous ligament is ruptured, and in severe cases of Dupuytren's fracture, the astragalus may be driven *upwards* between the bones of the leg. There is great broadening in the region of the ankle, and the malleoli are unduly prominent under the skin, which is tightly stretched over them. They are also nearer to the sole than normally. The movements of the ankle-joint are lost.

Dislocation of the *inferior tibio-fibular joint* is exceedingly rare, except in association with fractures of the lower ends of the bones of the leg, particularly Dupuytren's fracture, or with dislocation of the ankle-joint proper.

Treatment of Dislocations of Ankle.—The patient having been anæsthetised, the foot is extended and the knee and hip joints flexed to relax the calf muscles as completely as possible. Traction is then made upon the foot, while counter-extension is applied to the leg, and the bones are manipulated into position. Reduction usually takes place gradually without the characteristic snap which accompanies reduction of most dislocations. It is sometimes necessary to divide the tendo Achillis, particularly in cases of forward dislocation.

When the astragalus passes upwards between the tibia and fibula, it is sometimes impossible to effect reduction by manipulation, and the best results are then obtained by operation.

The after-treatment consists in keeping the leg on a pillow between sand-bags, and carrying out the usual massage and movement.

In compound dislocations which have become infected, primary amputation may be indicated, but in young and healthy subjects an attempt should be made to save the foot.

Dislocation of the astragalus from its articulations with the bones of the leg above and the os calcis and scaphoid below, is a comparatively common injury, and results from a violent wrench of the foot. It may be incomplete or complete. When the foot is plantar-flexed at the moment of injury, the displacement is generally *forward* with a tendency outward. The astragalus comes to rest on the external cuneiform and cuboid bones, the foot being adducted, inverted, and displaced bodily inward. In a large proportion of cases the dislocation is compound, more or less of the astragalus being forced through the skin (Fig. 232).

When the foot is dorsiflexed at the moment of injury the

displacement is *backward*, but this is rare, as are also *lateral dislocations*, and *dislocation by rotation*, in which the astragalus is rotated in its socket. In all these injuries the body of the astragalus loses its normal relationship with the malleoli.

An attempt should be made to reduce the dislocation under anæsthesia, the limb being placed in the same position as for reduction of dislocations of the ankle. While traction is made upon the foot, an assistant presses directly on the displaced bone and endeavours to manipulate it into position. In incomplete dislocations this usually succeeds, but it not infrequently fails in those which are complete, and under these circumstances it may be necessary to chisel through the external malleolus to admit of reduction, or to excise the astragalus.



FIG. 232.—Compound Dislocation of the Astragalus.

(Dr. Wm. Stewart's case.)

In most cases of compound dislocation also, the bone should be removed.

Sub-astragaloid Dislocation.—In this dislocation, which results from the same kinds of violence as the last, the astragalus retains its position in the tibio-fibular socket, and the os calcis and scaphoid, with the rest of the foot, are carried away from it. The body of the astragalus, therefore, maintains its normal relationship with the malleoli—a point of importance in the differential diagnosis between this injury and dislocation of the astragalus. The displacement is usually incomplete, and the foot may either pass backward and inward, or backward and outward. When the foot passes *backward and inward*, the head of the astragalus projects on the outer part of the dorsum, resting on the cuboid. The dorsum of the foot is shortened, the heel lengthened, the toes adducted, and the inner border of the foot raised. The external malleolus is unduly prominent, and reaches nearly to the sole.

In the *backward and outward* variety, the internal malleolus and head of the astragalus project unduly towards the inner side of the foot, which is abducted and everted.

In neither variety is there any mechanical obstacle to movement at the ankle-joint.

The *treatment* is carried out on the same lines as for dislocation of the astragalus, reduction being effected without difficulty in most cases. If this fails, as it occasionally does, it may be necessary to excise the astragalus.

Mid-tarsal or transverse tarsal dislocation—that is, at the astragalo-scaphoid and calcaneo-cuboid articulations—is extremely rare. The distal segment of the foot is usually displaced towards the sole; the foot is fore-shortened, the malleoli raised from the sole, the arch of the foot is lost, and the first row of tarsal bones project on the dorsum. The treatment consists in reducing the displacement by manipulation, after which massage and movement are employed.

Tarso-metatarsal Dislocations.—One, several, or all of the metatarsals may be separated from the distal row of tarsal bones—the usual cause being a fall from a horse, the foot being fixed in the stirrup. The bases of the metatarsal bones are displaced outward and toward the dorsum. The base of the second metatarsal and the internal cuneiform are sometimes fractured. Reduction by manipulation is generally easy in dorsal dislocations, but may be difficult when the bones are displaced externally. This may be due to fragments of bone or soft parts getting between the bones, and may necessitate operative interference. In old-standing dislocations, operation is to be advised only when locomotion is seriously interfered with.

Dislocations of the Toes.—The great toe may be dislocated at its metatarso-phalangeal joint, the base of the proximal phalanx passing towards the dorsum. Diagnosis and reduction are alike easy.

Inter-phalangeal dislocations are rare.

CHAPTER XXVIII

DISEASES OF BONE

Anatomy and physiology—Regeneration of bone—Transplantation of bone. DISEASES OF BONE—Definition of terms—Pyogenic diseases: *Acute osteomyelitis and periostitis*; *Chronic and relapsing osteomyelitis*; *Abscess of bone*—Tuberculous diseases—Syphilitic diseases—Hydatids; Rickets; Osteomalacia—Tumours of bone.

Surgical Anatomy.—During the period of growth, a long bone such as the tibia consists of a shaft or *diaphysis*, and two extremities or *epiphyses*. So long as growth continues there intervenes between the shaft and each of the epiphyses a disc of actively growing cartilage—the *epiphysial cartilage*; and at the junction of this cartilage with the shaft is a zone of young, vascular, spongy bone known as the ossifying or *epiphysial junction*. The shaft is a cylinder of compact bone enclosing the medullary canal, which is filled with yellow marrow. The extremities, which include the ossifying junctions, consist of spongy bone, the spaces of which are filled with red marrow. The articular aspect of the epiphysis is invested with a thick layer of hyaline cartilage, known as the *articular cartilage*.

The external investment of the bone—the *periosteum*—is thick and vascular during the period of growth, but becomes thin and less vascular when the skeleton has attained maturity. Except where muscles are attached it is easily separated from the bone; at the extremities it is intimately connected with the epiphysial cartilage and with the epiphysis, and at the margin of the latter it becomes continuous with the capsular ligament of the adjacent joint. It consists of two layers, an outer fibrous and an inner cellular layer, the latter being concerned with the formation of new bone.

The arrangement of the *blood-vessels* determines to some extent the incidence of certain diseases of bone. The nutrient artery, after entering the medullary canal through a special foramen in the cortex, bifurcates, and one main division runs towards each of the extremities of the bone, and terminates at the ossifying junction in a series of capillary loops projected against the epiphysial cartilage. This arrangement of capillary loops favours the lodgment of any organism which may be circulating in the blood, and partly accounts for the frequency with which diseases of bacterial origin develop in the region of the ossifying junction. The shaft of the bone is also nourished by numerous blood-vessels from the periosteum, which penetrate the cortex through the Haversian canals and anastomose with those derived from the

nutrient artery. The epiphyses are nourished by a separate system of blood-vessels, derived chiefly from the arteries which supply the adjacent joint. The veins of the marrow are of large calibre and are devoid of valves.

The *nerves* enter the marrow along with the arteries, and, being derived from the sympathetic system, are probably chiefly concerned with the innervation of the blood-vessels, but they are also capable of transmitting sensory impulses, as pain is a prominent feature of many bone affections.

The *function of the periosteum* is to form new bone. In diseased conditions the formation of new bone may be arrested, retarded, or exaggerated. In anterior poliomyelitis, for example, the function of the periosteum is often in abeyance, and the bones are abnormally thin and smooth. Increase in the activity of the periosteum results in an addition to the thickness or girth of the bone; when the new bone is added in a uniform layer on the surface, the condition is spoken of as *hyperostosis*; when it assumes the form of spicules or irregular out-growths, these are spoken of as *osteophytes*; and when it is heaped up so as to form a circumscribed elevation, this is described as a *node*.

The *marrow*, in addition to its blood-forming functions, is concerned in the absorption of bone which is in excess of physiological requirements. Under certain conditions—and especially from the prolonged irritation caused by pyogenic infection or by syphilis—the marrow assumes active bone-forming functions. This may lead to condensation of the spongy bone, and to diminution or obliteration of the medullary canal, whereby the bone becomes dense and heavy; to this condition the term *sclerosis* is applied. When the periosteum and marrow are simultaneously engaged in the formation of bone, a combination of hyperostosis and sclerosis results.

Under other conditions the absorption of lime salts and excavation of bone may be excessive, and the shaft may become soft and brittle, so that it is liable to bend under the weight of the body or to break from slight violence; this rarefaction of the bone is known as *osteoporosis*.

Hypertrophy of bone results when there is a physiological increase in the bone-forming functions of the periosteum or of the marrow, or of both combined, and *atrophy* when the formation of bone is retarded or arrested, or absorption is in excess of the normal. In the atrophy which accompanies old age, there is both diminished formation and excessive absorption of bone. Considerable interest attaches to that form met with in the neck of the femur, in which, while the bone retains its external form, there is excavation and enlargement of the marrow spaces at the expense of the osseous framework; this is sometimes described as *eccentric atrophy*.

The *function of the epiphysal cartilage* is to provide for the growth of the shaft in length. While all epiphysal cartilages contribute to this result, certain of them functionate more actively and for a longer period than others. Those at the knee, for example, contribute more to the length of the limb than do those at the hip or ankle, and they are also the last to unite. In the upper limb the more active epiphyses are at the shoulder and wrist, and these also are the last to unite.

The activity of the epiphysal cartilage may be modified as a result of disease. In rickets, for example, the formation of new bone may take place unequally, and may go on more rapidly in one half of the disc than in the other, with the result that the axis of the shaft comes to deviate from the normal, as in knock-knee and bow-knee. In

bacterial diseases originating in the marrow, if the epiphysial junction is directly involved in the destructive process, its bone-forming functions may be retarded or abolished, and the subsequent growth of the bone be seriously interfered with. On the other hand, if it is not directly involved but is merely influenced by the proximity of an inflammatory process, its bone-forming functions may be stimulated and the growth of the bone in length exaggerated. In paralysed limbs the growth from the epiphyses, although sometimes retarded or arrested, is usually little short of the normal. The result of interference with growth is more injurious in the lower than in the upper limb, because, from the functional point of view, it is essential that the lower extremities should be approximately of equal length. In the forearm or leg, where there are two parallel bones, if the growth of one is arrested the continued growth of the other results in a deviation of the hand or foot to one side.

In certain constitutional diseases, such as rickets and inherited syphilis, dwarfing of the individual results when all the epiphyses have their activities retarded.

Regeneration of Bone.—When bone has been lost or destroyed as a result of injury or disease, it is capable of being reproduced, the extent to which regeneration takes place varying under different conditions. The chief part in the regeneration of bone is played by the periosteum, in virtue of the active functions possessed by the osteoblasts on its deep surface. Provided the periosteum has been preserved, the whole shaft of a long bone may be reproduced after having been destroyed by disease or removed by operation. The reproductive capacity of the periosteum covering the epiphyses is usually more restricted. The periosteum of the flat bones of the skull and of the bones of the face, which are primarily developed in membrane, has very little capacity of forming new bone; hence, when bone has been lost or removed in these situations, there often results a permanent defect, even although the periosteum has been preserved. The marrow plays a minor part in the regeneration of bone.

Wounds or defects in articular cartilage are repaired by the formation of fibrous or osseous tissue derived from the subjacent marrow.

Transplantation of Bone—Bone-grafting.—There is still difference of opinion as to the fate of portions of bone which have been removed from their native soil and implanted elsewhere, or reimplanted in the situation from which they were detached. According to Barth and others, the implanted portion of bone remains quite passive, like any other aseptic foreign body, such as ivory or calcined bone, and is gradually penetrated by the surrounding vessels and tissue elements, and finally replaced by new bone. Clinical experience, however, is conclusive that a portion of bone which has been completely detached from its surroundings—for example, a trephine circle, or a flap of bone detached with the saw, or the loose fragments in a compound fracture—may unite if replaced in position, and may after an interval present a surface which is absolutely intact, while at its margins it is firmly and permanently incorporated with the surrounding bone. Embedded foreign bodies, on the other hand, such as ivory pegs or decalcified bone, exhibit, on removal after a sufficient interval, evidence of having been eroded, in the shape of worm-eaten depressions and perforations. It follows from this that the implanting of living bone with its periosteum is decidedly better than the implanting of macerated bone or other foreign material. In practice one may fill small defects with a flap of periosteum and bone taken from the tibia, the crest of the ilium, or from an amputated toe. When the shaft

of a long bone, such as the humerus or femur, has been resected, the fibula from the same subject, or the tibia from a recently amputated limb, may be inserted into the gap.

Transplanted living bone retains its vitality, not only when embedded in bone-forming tissues, but also when embedded in the soft parts, as is evidenced by the result of operations in which bone has been transplanted to form a new bridge to the nose.

DISEASES OF BONE

The different morbid processes met with in bone originate in the same way and lead to the same general results as do similar processes in other tissues. The structural peculiarities of bone, however, and the important changes which take place in the skeleton during the period of growth, modify certain of the clinical and pathological features.

Definition of terms.—Any inflammatory process that affects the periosteum is spoken of as *periostitis*; the term *osteomyelitis* is employed when the inflammation occurs in the marrow. In using these terms, however, it should be remembered that they indicate only the seat of the morbid process, but give no information regarding its nature. This is conveyed by prefixing such qualifying adjectives as pyogenic, tuberculous, or syphilitic to the terms periostitis or osteomyelitis. The term *ostitis* is intended to convey the idea of an inflammatory process in bone apart from periostitis or osteomyelitis; but it is doubtful if this ever occurs. The term *epiphysitis* has been applied to an inflammatory process in two distinct situations—namely, the ossifying nucleus in the epiphysis, and the ossifying junction between the epiphysial cartilage and the diaphysis. We shall restrict the term to inflammation in the first of these situations. Inflammation at the ossifying junction is included under the term osteomyelitis.

The term *rarefying ostitis* is applied to any inflammatory process which is attended with excessive absorption of the framework of a bone, whereby it becomes more porous or spongy than it was before, a condition known as *osteoporosis*. This is to be regarded as an accompaniment or as a result of different diseased conditions, rather than as a separate entity.

The term *caries* is employed to indicate any diseased process associated with crumbling away of the framework of a bone. It may be considered as the equivalent of ulceration in soft parts. The carious process is always preceded by the formation

of granulation tissue in the marrow or periosteum, and the erosion of the bone in contact with it. The subsequent caseation or liquefaction of the granulation tissue results in destruction of the trabecular framework, whereby the bone is rendered soft and friable. Clinically, carious bone yields a soft grating sensation under the pressure of the probe. The student should regard caries, not as a disease in itself, but as a result of different diseases, and should therefore always add a qualifying adjective, such as suppurative, tuberculous, or syphilitic, which will indicate its nature.

The term *dry caries* (*caries sicca*) is applied to that variety which is unattended with suppuration; it is illustrated by the changes met with in the articular surfaces in certain forms of tuberculous disease of joints.

Necrosis is the term applied to the death of a tangible portion of bone, and the dead portion when separated is called a *sequestrum*. The term *exfoliation* is sometimes employed to indicate the separation or throwing off of a superficial sequestrum. Necrosis is regarded as the equivalent of sloughing or gangrene in soft parts, and, like caries, is to be looked upon as the result of disease and not as a disease in itself.

BACTERIAL DISEASES

The most important diseases in this group are the pyogenic, the tuberculous, and the syphilitic.

PROGENIC DISEASES OF BONE.—These diseases result from infection with pyogenic organisms, and are most commonly met with while the growth of the skeleton is in active progress. The organisms reach their seat of action in the bones by way of the blood-stream; in certain cases the infection takes place directly, either through a wound or from a contiguous area of disease.

Diseases caused by the *Staphylococcus Aureus*.—As the majority of pyogenic diseases are due to infection with the *staphylococcus aureus*, these will be described first.

Acute osteomyelitis is a suppurative process beginning in the marrow and tending to spread to the periosteum. The disease is common in children, but is rare after the skeleton has attained maturity. Males are affected more often than females, in the proportion of three to one, probably because they are more exposed to injury and to violent exertion.

Etiology.—Infection takes place in various ways. In some cases a possible source of infection through the skin exists in

the form of eczema, acne pustules, small infected wounds, or septic conditions at the umbilicus. A mucous surface is perhaps a more frequent site of entrance of the cocci, as, for example, excoriations and fissures in the mouth and nose, adenoids, small tonsillar abscesses, or intestinal disturbances. Staphylococci may enter the general circulation and be deposited in the marrow, without there being any immediate evidence of such infection, or only such a minor disturbance of health as is indicated by slight indisposition or feverishness, and shooting "rheumatic" pains in the limbs. That they are capable of lying latent is evidenced by the fact that the disease may break out afresh many years after apparent cure.

Such conditions as, for example, a blow or other form of injury, some extra exertion such as a long walk, or exposure to cold, as in wading, may act as localising factors in the production of osteomyelitis.

The long bones are chiefly affected, and the following are the commonest sites of the disease: either end of the tibia; the lower end of the femur; the upper end of the humerus; the ulna, the fibula, the radius; the metatarsals, metacarpals, or phalanges. The other bones of the skeleton are only affected in rare instances.

Pathology.—As a rule the disease commences and is most intense in the ossifying junction at one end of the bone, and primarily affects the marrow. It may commence at both ends simultaneously—*bipolar osteomyelitis*; or, commencing at one end, may spread to the other.

The changes observed in the marrow are those of intense inflammation, gradually going on to purulent infiltration. Where the process is most advanced—that is, at the ossifying junction—there are evidences of absorption, rarefaction, and disappearance of the framework of the bone; the marrow spaces and Haversian canals are enlarged and filled with greenish-yellow pus. The cavities thus formed often communicate with the exterior by holes in the cortex, through which the pus may escape. The veins may become the seat of thrombosis and infective phlebitis.

The inflammation affects chiefly the shaft of the bone, and necrosis of a considerable portion, or even of the entire shaft, takes place rapidly—hence the name "acute necrosis" formerly applied to the disease. Doubtless the vitality of the bone is seriously impaired by the vascular and tissue changes which attend the process, but the actual death is the result of the action of the toxins.

The process may remain localised to the ossifying junction, may spread along the medullary canal for a varying distance, or may extend through the cortex to the periosteum by way of the Haversian canals. It then presents the features of periosteal suppuration, the pus accumulating under the periosteum and lifting it up from the bone. The periosteum of the diaphysis is easily separated—hence the facility with which the pus spreads along the shaft; but in the region of the ossifying junction it is raised with difficulty, because of its intimate connection with the epiphysial cartilage. Less frequently there are several collections of pus under the periosteum, each being derived from a focus of suppuration in the subjacent marrow. The pus perforates the periosteum, and makes its way to the surface by the easiest anatomical route, and discharges externally, forming one or more sinuses. The pus may spread to the adjacent joint, either directly through the epiphysis and articular cartilage, or by burrowing under the periosteum and capsule. When the epiphysis is intra-articular, as, for example, in the head of the femur, the pus infects the joint directly.

While the occurrence of purely periosteal suppuration is described by most authors, we are of opinion that the embolic form of osteomyelitis always originates in the marrow.

When there is marked absorption and destruction of bone at the ossifying junction, the epiphysis is liable to be separated—*epiphysiolysis*. The separation usually takes place through the ossifying junction, and the surfaces of the diaphysis and epiphysis are opposed to each other by irregular eroded surfaces bathed in pus. The separated epiphysis may be maintained in contact with the diaphysis by the periosteum, but when this has been detached by the formation of pus beneath it, the epiphysis is liable to be displaced by muscular action or by some movement of the limb. Except in cases where the epiphysis is displaced, the epiphysial cartilage usually remains intact, and continues its bone-forming functions. When it has been seriously damaged, however, the further growth of the bone in length may be interfered with. When intra-articular, as in the head of the femur, the epiphysis may die and separate as a sequestrum.

The adjacent joint may become filled with a serous effusion, which, on examination, is usually found to be sterile. When pus erupts into the joint, the lesion assumes the characters of a purulent arthritis, which, from its frequency during the earlier years of life, has been called *the acute arthritis of infants*.

Osteomyelitis is rare in the bones of the carpus and tarsus,

and the associated joints are usually infected from the outset. In flat bones, such as the skull, the scapula, or the ilium, suppuration usually occurs on both aspects of the bone.

Clinical Features.—The constitutional symptoms, which are due to the associated toxæmia, vary considerably in different cases. In mild cases they may be so slight as to escape recognition. In very severe cases the patient may succumb before there is any evidence of the localisation of the staphylococci in the bones. In average cases the temperature rises rapidly with a rigor and runs an irregular course with morning remissions, there is marked general illness accompanied by headache, vomiting, and sometimes delirium and convulsions.

The first local manifestations are pain and tenderness in relation to one of the long bones; the pain may be so severe as to prevent sleep and to cause the child to cry out. At a later stage there is swelling in the region of the ossifying junction, cedema, and dilatation of the superficial veins.

The swelling appears earlier, and is more definite, in superficial bones, such as the tibia, ulna, or clavicle, than in those more deeply placed, such as the upper end of the femur or humerus. It may be less evident to the eye than to the fingers, and is best appreciated by palpating the bone from the middle of its shaft towards the end. The maximum thickening and tenderness usually correspond to the junction of the shaft with the epiphysis, and the swelling tails off gradually towards the diaphysis. As time goes on there is diffuse redness of the skin, especially over a superficial bone, such as the tibia. The swelling becomes elastic and yielding, and gives definite evidence of fluctuation. This stage may be reached at the end of twenty-four hours, or not for some days.

Suppuration spreads towards the surface, until, some days later, the swelling bursts and pus escapes, after which the fever usually remits and the pain and other symptoms are relieved. The pus may contain blood and droplets of fat derived from the marrow, and in some cases minute particles of bone are present also. The presence of fat and bony particles in the pus establishes the medullary origin of the suppuration.

If an operation is performed, the periosteum is found to be raised from the bone, and the extent of the bare bone will be found to correspond fairly accurately with the extent of the lesion in the marrow.

Local Complications.—The adjacent joint may exhibit symptoms which vary from those of a simple effusion to those of a purulent *arthritis*. The joint symptoms may account for

little in the clinical picture, or may so predominate as to overshadow those of the bone lesion from which they originated.

Displacement of the epiphysis may take place insidiously, and reveal itself by an alteration in the attitude of the limb, which may resemble that of a dislocation; it is nearly always associated with suppuration in the adjacent joint.

When *pathological fracture* of the shaft occurs, as it may do, from some muscular effort or strain of the limb, it is attended with the usual signs of fracture.

Pathological dislocation has been chiefly observed at the hip; it may result from effusion into the joint with stretching of the ligaments, or may be the sequel of a purulent arthritis. Cases have been met with in which there is suppurative osteomyelitis in the femur on one side, and dislocation of the hip without suppuration on the other.

General Complications.—In some cases a *multiplicity of lesions* in the bones and joints imparts to the disease the features of pyæmia. The occurrence of septic endocarditis, as indicated by alterations in the heart sounds and the development of murmurs, may cause widespread infective embolism, and metastatic suppuration in the internal organs as well as in the bones and joints. The secondary suppurations are liable to be overlooked unless carefully sought for, as they are rarely attended with much pain.

In these forms of osteomyelitis the patient is dull and listless, or restless and talkative, or he may be actually delirious. The tongue is dry and coated, the lips and teeth are covered with sordes, the motions are constipated, or they may be loose and offensive, and may be passed involuntarily. The temperature is remittent and very irregular, the pulse small and rapid, and the urine scanty, and it may contain blood and albumen. Sometimes the skin shows erythematous and purpuric rashes, bleeding takes place from the nose and mouth, bed-sores form over the sacrum, the belly becomes swollen and sensitive, and the patient may cry out as in meningitis.

Differential Diagnosis.—Acute osteomyelitis is to be diagnosed from erysipelas, cellulitis, and other infections of the soft parts, and, in the case of the tibia, from erythema nodosum. Tenderness localised to the ossifying junction is one of the most valuable diagnostic signs of osteomyelitis.

When there is early and pronounced general intoxication, the severe forms of osteomyelitis are most likely to be confused with certain fevers, such as scarlet fever. In all febrile conditions in children and in young adults, the ossifying junctions

of the long bones should be examined for areas of pain and tenderness.

Acute osteomyelitis has many features in common with rheumatic fever, and some authorities believe them to be different forms of the same disease (Kocher, Sahli). In acute rheumatism, however, the joint symptoms and signs predominate, there is an absence of suppuration, and the pains and temperature yield to salicylates much more decidedly than in osteomyelitis.

The *prognosis* varies with the type of the disease, with its location—the vertebræ, skull, pelvis, and lower jaw being specially unfavourable—with the multiplicity of the lesions, and with the development of septic endocarditis and internal metastases.

Treatment.—This is carried out on the same lines as in other suppurative diseases.

In the earliest stages of the disease, the induction of hyperæmia for from twenty to twenty-two hours per day is the most efficient method of treatment. When the disease is further advanced and pus has formed, this should be let out, preferably by opening into the marrow in the vicinity of the ossifying junction, by means of a drill, gouge, or trephine. Instead of packing the cavity as was formerly the practice, Bier recommends that the skin edges should be brought together by sutures from four or five centimetres apart; these are loosely tied to afford sufficient space between them for the free exit of discharge, and the hyperæmic treatment is continued. Even although necrosis of the bone may not be prevented by these measures, it would appear that the hyperæmia favours the formation of new bone encasing the sequestrum, and also hastens the loosening of the latter.

When there is widespread suppuration in the marrow, and the bone is extensively bared of periosteum and appears likely to die *en masse*, the shaft may be resected either at this stage or after an interval of two or three days. Resection of the shaft is also indicated if the opening of the medullary canal is not followed by relief of symptoms.

Amputation of the limb is reserved for very grave cases, in which life is endangered by toxæmia. It may be called for later if the limb is likely to be useless, as, for example, when the whole shaft of the bone is dead without the formation of a new case, when epiphyses are displaced and the adjacent joints are disorganised.

Flat bones, such as the skull or ilium, must be trephined and

the pus cleared out from both aspects of the bone. In the vertebrae, operative interference is usually restricted to opening and draining any associated abscess.

In cases which are left to nature, and in which necrosis of bone has occurred, those portions of the periosteum and marrow which have retained their vitality, resume their osteogenetic functions, often to an exaggerated degree. Where the periosteum has been lifted up from the shaft by an accumulation of pus, or is in contact with bone which is dead, it proceeds to form new bone with great activity, so that the dead shaft becomes surrounded by a sheath or case of new bone, known as the *involucrum* (Fig. 233). Where the periosteum has been perforated by pus making its way to the surface, there are defects or holes in the involucrum, called *cloacae*. As these correspond more or less in position to the sinuses in the skin, in passing a probe down one of the sinuses it usually passes through a cloaca and strikes the dead bone lying in the interior. If the periosteum has been extensively destroyed, new bone may only be formed in small patches here and there, or not at all. The tissue cells and capillary loops on the internal aspect of the new case form a lining of granulations which, if in immediate contact with the denuded bone, eat into its surface and



FIG. 233.—Shaft of Femur after Acute Osteomyelitis. The shaft has undergone extensive necrosis, and a shell of new bone has been formed by the periosteum.

partly absorb it. The bone in process of separation thus

acquires a pitted, grooved, or worm-eaten appearance, and undergoes diminution in size. If the periosteal surface of the bone is bathed in pus, it remains smooth and intact. The separation of the dead bone from the living is effected by granulation tissue aided by osteoclasts, which eat into the living as well as into the dead bone, so that separation takes place at the expense of both. Ultimately the dead bone becomes loose and forms a sequestrum which is usually white, but may be discoloured by the products of decomposition. The separation of the sequestrum takes place more rapidly in the spongy bone of the ossifying junction than in the compact bone of the shaft.

When foci of suppuration have been scattered up and down the medullary cavity, and the bone has died in patches, several sequestra may be included by the new case; each portion of dead bone is slowly separated, and comes to lie in a cavity lined by granulations.

As a result of formation of new bone by the marrow, the medullary canal may be obliterated, and the bone becomes heavier and denser, and is said to be sclerosed. Wherever the periosteum has not been detached, the new bone which it forms is deposited on the original shaft, and results in an increase in the girth of the bone—hyperostosis.

Pathological fracture of the shaft may occur at the site of necrosis, when the new case is incapable of resisting the strain put upon it, and is most frequently met with in the shaft of the femur. Short of fracture, there may be bending or curving of the new case, and this results in deformity and shortening of the limb (Fig. 234).

The *extrusion of a sequestrum* may occur, provided there is a cloaca large enough to allow of its escape, but the surgeon has usually to interfere by performing the operation of sequestrectomy. Displacement or partial extrusion of the dead bone may cause serious complications, as when a sequestrum derived from the trigone of the femur perforates the popliteal artery or the cavity of the knee-joint, or a sequestrum of the pelvis perforates the wall of the urinary bladder. *and*

The extent to which bone which has been lost is reproduced varies in different parts of the skeleton: while the long bones, the scapula, the lower jaw, and other bones which are developed in cartilage are almost completely reproduced, bones which are entirely developed in membrane, such as the flat bones of the skull and the upper jaw, are not usually reproduced.

Sequelæ of Acute Suppurative Osteomyelitis.—The commonest

sequel is the presence of a sequestrum with one or more discharging sinuses; these sinuses have rigid edges which are usually depressed and adherent to the subjacent bone.

The Recognition and Removal of Sequestra.—So long as dead bone remains in position, there will be suppuration from the granulations lining the cavity in which it lies, and a discharge of pus from the sinuses.

The dead bone may be evident to the eye, but it is usually only recognised on passing a probe down a sinus. It is not easy from such examination to determine the size, character, or number of the sequestra, or to be certain that they are loose, but these points may be cleared up by examination with the X-rays.



FIG. 234.—Large Sequestrum of Lower Part of Shaft of Femur partly surrounded by New Bone; the latter is bent as a result of fracture which took place $2\frac{1}{2}$ years before amputation.

(Museum, Royal College of Surgeons, Edinburgh.)

The traditional practice is to wait until the dead bone is entirely separated before undertaking any operation for its removal, from fear, on the one hand, of leaving portions behind which may afterwards die, or, on the other, of removing more bone than is necessary. In our opinion this practice need no longer be rigidly adhered to, as by operating at an earlier stage healing is greatly hastened. If it is decided to wait for separation of the dead bone, drainage should be improved, and the septic element combated by the induction of hyperæmia.

The operation for the removal of the dead bone (*sequestrectomy*) consists in opening up the periosteum and the new case sufficiently to allow of the removal of all the dead bone, including the most minute sequestra, and infected granulation tissue. The limb having been rendered bloodless, existing sinuses are enlarged, but if these are inconveniently situated—for example, in the centre of the popliteal space in necrosis of the femoral trigone—it is better to make a fresh wound down to the bone on that aspect of the limb which affords the best access, and which entails the least injury of the overlying soft parts. The periosteum, which is thick and easily separable, is raised from the new case with an elevator,

and with the chisel or gouge enough of the newly formed bone is taken away to allow of the removal of the sequestrum. Care must be taken not to leave behind any fragment of dead bone, as this will interfere with healing, or may determine a relapse of suppuration.

The dead bone having been removed, the lining granulations are scraped away with a sharp spoon, and the cavity is disinfected.

There are different ways of dealing with a *bone cavity*. It may be packed with iodoform gauze, which is changed at intervals until healing takes place from the bottom; it may be filled with a flap of bone and periosteum raised from the vicinity, or with bone grafts; or the wall of bone on one side of the cavity may be chiselled through at its base, so that it can be brought into contact with the opposite wall. The method of filling bone cavities devised by Mosetig-Moorhof, consists in disinfecting and drying the cavity by a current of hot air, and filling it with a mixture of powdered iodoform (60 parts) and oil of sesame and spermaceti (each 40 parts), which is fluid at a temperature of 112° F.; the soft parts are then brought together without drainage. As the cavity fills up with new bone the iodoform is gradually absorbed.

Such procedures may be carried out at the same time as the sequestrum is removed, or after an interval.

The *deformities* resulting from acute osteomyelitis are more marked the earlier in life the disease occurs. *Shortening* is not uncommon from interference with growth at the ossifying junction. *Exaggerated growth* in the length of a bone is rare, and has been observed chiefly in the bones of the leg. Where there are two parallel bones—as in the leg, for example—the growth of the diseased bone may be impaired, and the other continuing its normal growth becomes disproportionately long; less frequently the growth of the diseased bone is exaggerated, and it becomes the longer of the two. In either case, the longer bone becomes curved. An *obliquity* of the bone may result when one half of the epiphysal cartilage is destroyed and the other half continues to form bone, and this gives rise to such deformities as knock-knee and club-hand.

Deformity may also result from vicious union of a pathological fracture, permanent displacement of an epiphysis, contracture, ankylosis, or dislocation of the adjacent joint.

Serous or Albuminous Osteomyelitis and Periostitis.—This is a mild, localised, and rare form of the disease, due to an attenuated virus, and accompanied by an effusion of serous

fluid under the periosteum, but with no tendency to pass on to suppuration or to be followed by necrosis.

Growth fever is also sometimes to be regarded as an attenuated form of osteomyelitis, which results in an exaggerated growth in length of the bones affected. It is probably one of the causes of the condition popularly known as "growing pains."

The milder cases are not attended with fever, the child complains of vague evanescent pains, and of feeling tired, so that he is disinclined to go about.

In the more severe forms the child is obviously ill, is weary, and disinclined to get up, has pains in the head and in the region of the joints of the limbs, and towards evening the temperature may rise considerably. The illness is sometimes sudden and acute, and may last for two or three days; or it may be milder and more prolonged, and there may be several relapses within twelve months.

During the persistence of the pains the child should be kept at rest with the affected limb immobilised.

Relapsing Osteomyelitis.—As the term indicates, the various forms of relapsing osteomyelitis all date back to an antecedent attack, and their occurrence depends on the capacity of staphylococci to lie latent in the marrow.

Relapse may take place within a few months of the original attack, or not for many years, and there may be repeated outbreaks. Cases are sometimes met with in which outbreaks recur at regular intervals for several years, the tendency, however, being for the attacks to become milder as the virulence of the organisms becomes attenuated. Osteomyelitis in a patient over twenty-five is nearly always of the relapsing variety.

Clinical Features—In some cases the bone becomes enlarged, and the patient complains of pain and tenderness on pressure; in others there are the usual phenomena which attend suppuration, but the pus is slow in coming to the surface, and the constitutional symptoms are slight. The pus may escape by new channels, or one of the old sinuses may re-open. If a sequestrum forms, it is usually walled in by new bone and difficult to discover.

Treatment.—In cases of hyperostosis and sclerosis with persistent and severe pain, if relief is not afforded by the repeated application of blisters, the thickened periosteum should be incised, and the bone opened up with the chisel or trephine. In cases attended with suppuration, the swelling

is incised and drained, and if there is a sequestrum, it must be removed.

Circumscribed Abscess of Bone—"Brodie's Abscess."—The most important form of relapsing osteomyelitis is the circumscribed abscess of bone described first by Benjamin Brodie. It is usually met with in young adults. Several years may intervene between the original attack of osteomyelitis and the onset of symptoms of abscess.

*Morbid Anatomy.*¹

—The abscess is nearly always situated in the central axis of the bone in the region of the ossifying junction, although cases are occasionally met with in which it lies nearer the middle of the shaft. In exceptional cases there is more than one abscess (Fig. 235).

The tibia is the bone most commonly affected, but the lower end of the femur, or either end of the humerus, may be the seat of the abscess. In the quiescent stage the lesion is represented by a small cavity in the bone, filled with clear



FIG. 235.—Segment of Tibia resected for Brodie's Abscess. The specimen shows two separate abscesses.

serum, and lined by a fibrous membrane which is engaged in forming new bone. Around the cavity the bone is sclerosed, and the medullary canal may be obliterated. When the process goes on to the formation of an abscess, the contents of the cavity are transformed into a greenish-yellow pus from which the staphylococcus can be isolated, and the

¹ Alexis Thomson, *Edin. Med. Journ.*, 1906.

cavity is lined by a thin film of granulation tissue, which erodes the surrounding bone and so causes the abscess to increase in size. If the erosion proceeds uniformly, the cavity is spherical or oval; if it is more active at some points than others, diverticula or tunnels are formed, and one of these may finally erupt through the shell of the bone on a periosteal surface or into an adjacent joint. Small irregular sequestra are occasionally found within the abscess cavity. In long-standing cases it is common to find extensive obliteration of the medullary canal, and an increase in the girth of the bone from new formation by the periosteum.

The size of the abscess ranges from that of a cherry to that of a walnut, but specimens found in museums show that, if left to nature, the abscess may attain much greater dimensions.

The affected bone is not only thicker and heavier than normal, but may also be curved or otherwise deformed.

The *clinical features* are almost exclusively local. Pain, due to tension within the abscess, is the dominant symptom. At first it is vague and difficult to localise, later it is referred to the interior of the bone, and is described as "boring." It is aggravated by using the limb, and there are often, especially during the night, exacerbations in which the pain becomes excruciating. In the early stages there are remissions of days or weeks, during which the symptoms entirely disappear, but as the abscess increases these become shorter, until the patient is hardly ever free from pain. Localised tenderness can almost always be elicited by percussion, or by pressing the bone between the fingers and thumb. The pain induced by the traction of muscles attached to the affected bone, or by the strain of the weight of the body, may interfere with the function of the limb, and in the lower extremity cause a limp in walking. The limb may be disabled from involvement of the adjacent joint, in which there may be an intermittent hydrops which comes and goes coincidentally with exacerbations of pain; or the abscess may perforate into the joint and set up an acute arthritis.

The differential *diagnosis* of Brodie's abscess from other affections met with at the ends of long bones, and particularly from tuberculosis, syphilis, and new growths, is made by a consideration of the previous history, especially with reference to an antecedent attack of osteomyelitis. Examination with the X-rays reveals in a considerable number of cases an ill-defined light area in the centre of a dark shadow; if the zone of sclerosis around the abscess is well marked, this light area

is wanting, and a uniform dark shadow is cast, which of itself is usually sufficient to exclude a central gumma or new growth. When the adjacent joint is implicated, the surgeon may be misled by the patient referring his symptoms to the joint rather than to the bone.

Treatment.—If an abscess is suspected, there should be no hesitation in exploring the interior of the bone. It is exposed by a suitable incision, and the periosteum reflected, the bone opened up by a trephine or chisel, and the presence of an abscess may be at once indicated by the escape of pus. If, owing to the small size of the abscess or the density of the bone surrounding it, the pus is not reached by this procedure, the bone should be drilled in different directions. The pus and any dead bone having been cleared out, the cavity is dealt with as described on p. 637.

Osteomyelitis which is Chronic from the Outset.—That there is a chronic form of pyogenic osteomyelitis has only been recognised within recent years. Formerly it was confused with syphilis and tubercle, and without bacteriological examination it is still difficult to differentiate between these affections. Like relapsing osteomyelitis, it may assume the form of hyperostosis and sclerosis, of suppurative osteomyelitis with or without necrosis, or of chronic abscess of bone.

Necrosis without suppuration, described by Paget under the name "quiet necrosis," is a rare disease, and would appear to be associated with an attenuated form of staphylococcal infection (Tavel). It occurs in adults, being met with up to the age of fifty or sixty, and is characterised by the insidious development of a swelling which involves a considerable extent of a long bone. The pain varies in intensity, and may be continuous or intermittent, and there is tenderness on pressure. The shaft of the bone is increased in girth as a result of its being surrounded by a new case derived from the periosteum. The resemblance to sarcoma may be very close, but the swelling is not as defined as in sarcoma, nor does it ever assume the characteristic "leg of mutton" shape. In both diseases there is a tendency to pathological fracture. It is difficult also to differentiate the condition from syphilitic and from tuberculous disease. If the diagnosis is not established after examination with the X-rays, an exploratory incision should be made; if dead bone is found, it is removed.

Osteomyelitis due to Pyogenic Infections other than the Staphylococcus Aureus.—The *staphylococcus albus*, the *streptococcus pyogenes*, and the *pneumococcus*, for example, sometimes

cause osteomyelitis, particularly in young subjects, but the disease is, as a rule, of a milder type than that caused by the staphylococcus aureus, is attended with less profuse suppuration, and is not so liable to be followed by necrosis. In the streptococcal and pneumococcal forms the adjacent joint is not infrequently affected.

The Typhoid Bacillus.—In typhoid fever the bone marrow is markedly congested, and is liable to be invaded by bacilli which may set up osteomyelitis soon after their lodgment, or may lie latent for a considerable period before doing so. The lesions in the bones may be single or multiple, they may involve the marrow or the periosteum or both, and they may or may not be attended with suppuration. They are most commonly met with in the tibia and in the ribs at the costochondral junctions.

The bone lesions usually occur during the seventh or eighth week of the fever, but have been known to occur much later. The chief complaint is of vague pains, at first referred to several bones, later becoming localised in one; they are aggravated by movement, or by handling the bone, and are worst at night. There is redness and œdema of the overlying soft parts, and swelling with vague fluctuation, and on incision there escapes a yellow creamy pus, or a brown syrupy fluid containing the typhoid bacillus in pure culture. Necrosis is exceptional.

When the abscess develops very slowly, the condition may resemble tuberculous disease, from which it may be diagnosed by the history of typhoid fever, and by obtaining a positive Widal reaction.

The prognosis is favourable, but recovery is apt to be slow, and relapse is not uncommon.

It is usually sufficient to incise the periosteum, but when the disease occurs in the ribs it may be necessary to resect portions of these bones.

Pyogenic Diseases of Bone due to Spread of Infection from the Soft Parts.—There still remain those forms of osteomyelitis which result from infection through a wound involving the bone—for example, compound fractures, gun-shot injuries, osteotomies, amputations, resections, or operations for un-united fracture. In all of these the marrow is exposed to infection by such organisms as may be present in the wound. A similar form of osteomyelitis may occur apart from a wound—for example, infection may spread to the jaws from lesions of the mouth; to the skull, from lesions of the scalp or of the cranial

bones themselves—such as a syphilitic gumma or a sarcoma which has fungated externally; or to the petrous temporal, from suppuration in the middle ear.

The lesions included in this group have become much rarer since the introduction of Listerian surgery; in former times they were commonly met with, as is evidenced by the number of specimens in museums. Those in the University of Edinburgh were derived chiefly from the wars in the Peninsula.

The most common is an osteomyelitis commencing in the marrow exposed in the wound, which presents the changes characteristic of ordinary suppuration. In amputation stumps, fungating granulations may protrude from the sawn end of the bone, and if necrosis takes place, the sequestrum is annular, affecting the cross section of the bone at the saw-line; or tubular, extending up the shaft, and tapering off above. The periosteum is more easily detached, is thicker than normal, and is usually actively engaged in forming bone. In the macerated specimen, the new bone presents a characteristic coral-like appearance, and may be perforated by cloacæ (Fig. 236).

Like other septic infections, it may terminate in pyæmia, as a result of septic phlebitis in the marrow.

The *clinical features* of osteomyelitis in an amputation stump are those of ordinary pyogenic infection; the bone lesion may not even be recognised unless the bone is exposed to view. Healing does not take place until the sequestrum is thrown off or removed.

In *compound fractures*, if a fragment dies and forms a sequestrum, it is apt to be walled in by new bone, and the sinuses continue to discharge until the sequestrum is removed. Even after healing has taken place, relapse is liable to occur, especially in gun-shot injuries. Months or years afterwards, either without apparent cause or after some extra strain of the



FIG. 236. — New Periosteal Bone on surface of Femur from Amputation Stump. Osteomyelitis supervened on the amputation, and resulted in necrosis at the sawn section of the bone.

(Anatomical Museum, University of Edinburgh.)

limb or exposure to cold and wet, the bone may become painful and tender. The symptoms may subside under rest and elevation of the limb and the application of a compress, or an abscess forms and bursts with comparatively little suffering. The contents may be clear yellow serum or watery pus; sometimes a small spicule of bone is discharged.



FIG. 237. —Tapering, Tubular Sequestrum of Femur, due to Osteomyelitis following amputation.

TUBERCULOUS DISEASES

The tuberculous diseases of bone result from infection of the marrow or periosteum by tubercle bacilli conveyed through the arteries; it is exceedingly rare for tubercle to appear in bone as a primary infection, the bacilli being usually derived from some pre-existing focus in the bronchial glands or elsewhere. These diseases are characterised by their insidious onset and slow progress, and by the frequency with which they are associated with disease of the adjacent joint. The association of bone and joint disease is explained by the tendency which tubercle has to attack the articular

extremities of long bones and the marrow of short bones—for example, those of the carpus or tarsus. Volkmann, König, Watson Cheyne, and Stiles should be mentioned as among those who have contributed most to our knowledge of the tuberculous diseases of bone.

Tuberculous Periostitis is met with in the ribs, sternum, spinal column, skull, and less frequently in the long bones of the limbs. It may originate in the periosteum, or may spread thence from the marrow.

In superficial bones, such as the sternum, the formation of tuberculous granulation tissue in the deeper layer of the periosteum, and its subsequent caseation and liquefaction, is attended by the insidious development of a doughy swelling in relation to the bone, which is not as a rule painful, although it is tender on pressure. While the swelling may remain

for some time without change, it eventually increases in size, becomes boggy or fluctuating, and assumes the characters of a cold abscess. The pus perforates the fibrous layer of the periosteum, invading and infecting the overlying soft parts, its spread being influenced by the anatomical arrangement of the tissues. The size of the abscess affords no indication of the extent of the bone lesion from which it originates. As the abscess reaches the surface, the skin becomes of a dusky red or livid colour, is gradually thinned out, and finally gives way, forming a sinus. A probe passed into the sinus strikes carious bone. The sinus persists as long as any active tubercle remains in the tissues, and is apt to form an avenue for pyogenic infection. Small sequestra may sometimes be found embedded in the granulation tissue formed in relation to the periosteum.

In deeply seated bones, such as the upper end of the femur, the formation of a cold abscess in the soft parts is often the first evidence of disease in the periosteum, and its true source and nature may only be recognised on incising the abscess and exploring its interior.

Diagnosis.—Before the stage of cold abscess is reached, the localised swelling over the bone is to be differentiated from a syphilitic gumma, from chronic forms of staphylococcal osteomyelitis, from certain forms of enlarged bursa or of ganglion, from subperiosteal lipoma, and from sarcoma. Most difficulty may be met with in relation to periosteal sarcoma, which, however, is characterised by its rapid and continuous progress, by the severity and persistence of pain in spite of rest, and by the absence of suppuration. A rise of temperature in the evening is more likely to be present in cases of rapidly growing sarcoma than in tubercle, unless the latter is complicated with pyogenic

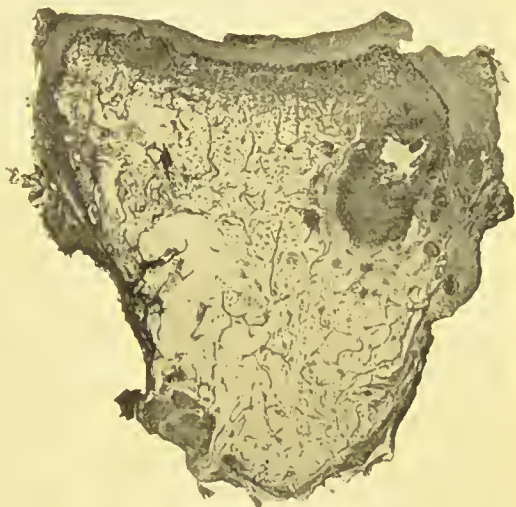


FIG. 238.—Tuberculous Osteomyelitis of Os Magnum, excised from a boy æt. 8. Note well-defined caseous focus, with several minute foci in surrounding marrow.

infection. The X-rays, in the case of tubercle, show a superficial erosion of the bone, while in sarcoma there is usually a considerable formation of new bony material. After employing one of the tuberculin tests, the final appeal is to exploratory incision, and to histological and bacteriological examination of the diseased tissue.

The early recognition of periosteal lesions in the region of the articular ends of long bones is of importance, as the disease, when left to itself, is liable to spread to the adjacent joint.



FIG. 239.—Advanced Tuberculous Disease in region of Ankle. The ankle-joint is ankylosed, and there is a large sequestrum in the os calcis.

(Specimen in Anatomical Museum, University of Edinburgh.)

The *treatment* is that of tuberculous lesions in general; if conservative measures fail, the choice lies between the injection of iodoform, and open incision and removal of the infected tissues with the sharp spoon. In the case of the ribs it is more satisfactory to remove the diseased portion of bone. If all the tubercle has been removed and the skin is healthy, the wound may be stitched up with the object of obtaining primary

union; otherwise it is treated by the open method.

Tuberculous Osteomyelitis.—Tuberculous lesions in the marrow occur as isolated or as multiple foci of granulation tissue, which replace the marrow and eat away the trabeculae of bone in the vicinity (Fig. 238). If the process spreads in the marrow as a diffuse caseous infiltration, death of bone on a considerable scale may ensue, giving rise to sequestra. When these involve an articular surface they are usually wedge-

shaped (Fig. 294); in other situations they are rounded or irregular. When the death of bone is preceded by sclerosis, the sequestrum is denser than normal bone. Finally, the sequestrum lies loose in a cavity lined by tuberculous granulation tissue. In diffuse lesions of the shaft of a long bone, the continued absorption of bone in the interior, while new bone is laid down by the periosteum, results in an "expansion" of the bone to which the name *spina ventosa* was formerly applied (Figs. 240, 241).

Clinical Features.—As a rule, it is only in superficially placed bones, such as the tibia, ulna, clavicle, lower jaw, or phalanges, that tuberculous disease in the marrow gives rise to signs sufficiently definite to allow of its clinical recognition. In the vertebræ, or in the bones of deeply seated joints, such as the hip or shoulder, the existence of tuberculous lesions in the marrow may only be inferred from indirect signs—such, for example, as rigidity and curvature in the case of the spine, or from the symptoms of grave and persistent joint-disease in the case of the hip or shoulder.

With few exceptions, tuberculous disease in the interior of a bone does not reveal its presence until by extension it reaches one or other of the surfaces of the bone. In the shafts of long bones its eruption on the periosteal surface is usually followed by the formation of a cold abscess in the overlying soft parts. When situated in the articular ends of bones, the disease more often erupts in relation to the reflection of the synovial membrane or directly on the articular surface—in either case giving rise to disease of the joint (Fig. 266).

Diffuse tuberculous osteomyelitis of the shaft of a long bone is comparatively rare, and has been observed chiefly in



FIG. 240. — Enlargement of Lower End of Humerus and Upper End of Ulna, the result of Tuberculous Osteomyelitis. The term *spina ventosa* is applicable to the condition of the upper end of the ulna.

(Museum of Royal College of Surgeons, Edinburgh.)

the tibia and in the ulna in children (Fig. 242). The disease commences at the growing extremity of the diaphysis, and spreads along the medulla to a variable extent; it is attended

by the formation of a sheath of new periosteal bone, which causes thickening of the diaphysis, and in the early stage of the disease this is the only sign present. A good radiogram will not only confirm the diagnosis, but, in many instances, demonstrates quite distinctly the position, size, and shape of the tuberculous focus, the presence or absence of a sequestrum, and the thickness and extent of the subperiosteal sheath of new bone. As the tuberculous lesion progresses, first the cancellous, then the cortical, and ultimately the new subperiosteal bone becomes invaded at one or other part of its circumference. Finally, the periosteum gives way, and a deep-seated abscess is produced; this sooner or later becomes superficial, and if left to itself ruptures externally, leaving a chronic sinus (Stiles). The method of *treatment* usually adopted is, after freely opening up the bone with a chisel, to gouge and scrape away the infected tissues. It is much more satisfactory to resect subperiosteally the diseased portion of the diaphysis, the bone being divided with a wire saw well above and below the infected area (Stiles).

In cancellous bones, such as those of the tarsus, there is caseous infiltration in the marrow, and this is often attended with the formation of sequestra either in the interior of the bone or involving its outer shell, as shown in Fig. 239. The situation and extent of the disease are usually to be recognised in X-ray photographs. After the tuberculous granulation tissue erupts through the cortex of the bone, it gives rise to a cold abscess or infects adjacent joints and tendon sheaths.

FIG. 241.—Expansion of Proximal Phalanx (*spina ventosa*) in Tuberculous Dactylitis.



If an exact diagnosis is made at an early stage of the disease—and this is often possible with the aid of X rays—the affected bone is excised, or its interior is cleared out with the sharp spoon and gouge, the latter procedure being preferred in the case of the *os calcis* to conserve the stability of the heel. When several bones and joints are simultaneously affected, and there are sinuses with mixed infection, amputation is usually indicated, especially in adults.



FIG. 242.—Diffuse Tuberculous Osteomyelitis of Right Tibia.

(Photograph lent by Mr. Stiles.)

Tuberculous dactylitis is the name applied to a diffuse form of tuberculous disease affecting the phalanges, metacarpal or metatarsal bones. When the disease has originated in the marrow, the macerated bone may present the appearance of having been expanded—the *spina ventosa* of earlier writers (Fig. 241)—due to the replacement of the original bone by granulation tissue and the continuous formation of new bone by the periosteum. In some cases the shaft of the bone dies, in part or in its entirety, and constitutes a sequestrum.

Although dactylitis is usually due to disease in the marrow, it may also result from disease in the periosteum.

The *clinical features* are those of a spindle-shaped swelling of a finger or toe, indolent, painless, and interfering but little with the function of the digit affected. Recovery may eventually occur without suppuration, but in untreated cases it is very common to have the formation of a cold abscess, which bursts and forms one or more sinuses. It may be difficult to differentiate tuberculous dactylitis from the enlargement of the



FIG. 243.—Multiple Tuberculous Dactylitis.
(From a photograph lent by Sir George T. Beatson.)

phalanges in inherited syphilis (syphilitic dactylitis), especially when the tuberculous lesion occurs in a child who is the subject of inherited syphilis. In the syphilitic lesion, skiagrams usually show a more abundant formation of new bone, but in many cases the doubt is only cleared up by observing the results of the tuberculin test or the effects of anti-syphilitic treatment.

Treatment.—Recovery under conservative measures is not uncommon, and the functional

results are usually much better than those following upon operative treatment, although in either case the affected finger is liable to be dwarfed (Fig. 244). The fingers should be immobilised in a splint, and a Bier's bandage applied to the upper arm. Operative interference is indicated if a cold abscess develops, if there is a persistent sinus, or if a sequestrum has formed, a point upon which information is obtained by examination with the X-rays. When the toes are affected, amputation should be recommended, but it is rarely

called for in the fingers unless the disease is threatening to spread along the lymphatics, or is affecting the general health. It is more often required in adults than in children.

SYPHILITIC DISEASES OF BONE

Syphilitic affections of bone may be met with at any period of the disease, but the graver forms occur chiefly in the tertiary stage of acquired and inherited syphilis. The virus is carried by the blood-stream to all parts of the skeleton, but the local development of the disease appears to be influenced by some predisposition on the part of individual bones, and by external factors such as injury.

Syphilitic diseases of bone are much less common in practice than those due to pyogenic and tuberculous infections, and they show a marked predilection for certain bones, notably the tibia, sternum, and skull. They differ from tuberculous affections in the frequency with which they attack the shafts of long bones rather than the articular ends, and in the comparative rarity of joint complications.

Evanescent periostitis is met with in acquired syphilis during the period of the early skin eruptions. The patient complains, especially at night, of pains over the frontal bone, ribs, sternum, tibiæ, and ulnæ. Localised tenderness is elicited on pressure, and there is slight swelling, which, however, rarely amounts to what may be described as a *periosteal node*.

In the later stages of acquired syphilis, *gummatous periostitis* and *osteomyelitis* occur, and are characterised by the formation in the periosteum and marrow of circumscribed gummata or of a diffuse gummatous infiltration. The framework of the



FIG. 244.—Shortening of Middle Finger of Adult, the result of Tuberculous Dactylitis in childhood.

bone is rarefied in the area immediately involved, and condensed in the parts beyond. If the gummatous tissue degenerates and breaks down, and especially if the overlying skin is perforated and septic infection is superadded, the bone disintegrates and exhibits the condition known as *syphilitic caries*; sometimes a portion of bone has its blood-supply so far interfered with by the gummatous tissue that it dies—*syphilitic necrosis*. Syphilitic sequestra are nearly always heavier and denser than normal bone, because sclerosis usually

precedes necrosis. The bones specially affected by gummatous disease are: the skull, the septum of the nose, the nasal bones, palate, sternum, femur, tibia, and the bones of the forearm.

In the bones of the skull, gummata may form in the pericranium, diploë, or dura mater. An isolated gumma forms a firm elastic swelling, shading off into the surroundings. In the macerated bone there is a depression or an actual perforation of the calvaria; multiple gummata tend to fuse with one another at their margins, giving the appearance of a combination of circles: these sometimes surround



FIG. 245.—Syphilitic Disease of Skull, showing areas of necrosis in process of separation.

(Museum of Royal College of Surgeons, Edinburgh.)

an area of bone and cut it off from its blood-supply (Fig. 245). If the overlying skin is destroyed and septic infection superadded, such an isolated area of bone is apt to die and furnish a sequestrum; the separation of the dead bone is extremely slow, partly from the want of vascularity in the sclerosed bone round about, and partly from the density of the sequestrum. In exceptional cases the necrosis involves the entire vertical plate of the frontal bone. There is suppuration between the bone and the dura (suppurative pachymeningitis), and this may be followed by cerebral abscess or by pyæmia. Gummatous disease in the wall of the orbit may cause protrusion of the eye and paralysis of the ocular muscles.

On the inner surface of the skull, the formation of gummatous tissue may cause pressure on the brain and give rise to intense pain in the head, Jacksonian epilepsy, or paralysis, the symptoms varying with the seat and extent of the gumma. The cranial nerves may be pressed upon at the base of the skull, especially at their points of exit, and this gives rise to symptoms of irritation or paralysis in the area of distribution of the nerves affected.

In the septum of the nose, the nasal bones, and the hard palate, gummatous disease in the periosteum causes ulceration, which, beginning in the mucous membrane, spreads to the bones, and being complicated with septic infection leads to caries and necrosis. In the nose, the disease is attended with stinking discharge (ozæna), the extrusion of portions of dead bone, and subsequently with deformity characterised by loss of the bridge of the nose; in the palate, it is common to have a perforation, so that the air escapes through the nose in speaking, giving to the voice a characteristic nasal tone.

Syphilitic disease of the tibia may be taken as the type of the affection as it occurs in the long bones. Gummatous disease in the periosteum may result in the formation of a well-defined node, or the whole shaft may become the seat of an irregular nodular enlargement (Fig. 247). If the bone is inacerated, it is found to be heavier and bulkier than normal; there is diffuse sclerosis with obliteration of the medullary canal, and the surface is uneven from heaping up of new bone by the periosteum—hyperostosis (Fig. 246). If a periosteal gumma breaks down and invades the skin, a syphilitic ulcer is formed with carious bone at the bottom (Fig. 248). A central gumma may eat away the surrounding bone to such an extent that it readily undergoes pathological fracture. In the rare cases in which it attacks the articular end of a long bone, gummatous disease may implicate the adjacent joint and give rise to syphilitic arthritis.



FIG. 246.—Syphilitic Hyperostosis and Sclerosis of Tibia, on section and on surface view.

Clinical Features.—There is severe boring pain—as if a gimlet were being driven into the bone. It is worst at night, sometimes preventing sleep, and has been ascribed to compression of the nerves in the narrowed Haversian canals.

The *periosteal gumma* appears as a smooth, circumscribed swelling which is soft and elastic in the centre and firm at the margins, and shades off gradually into the surrounding

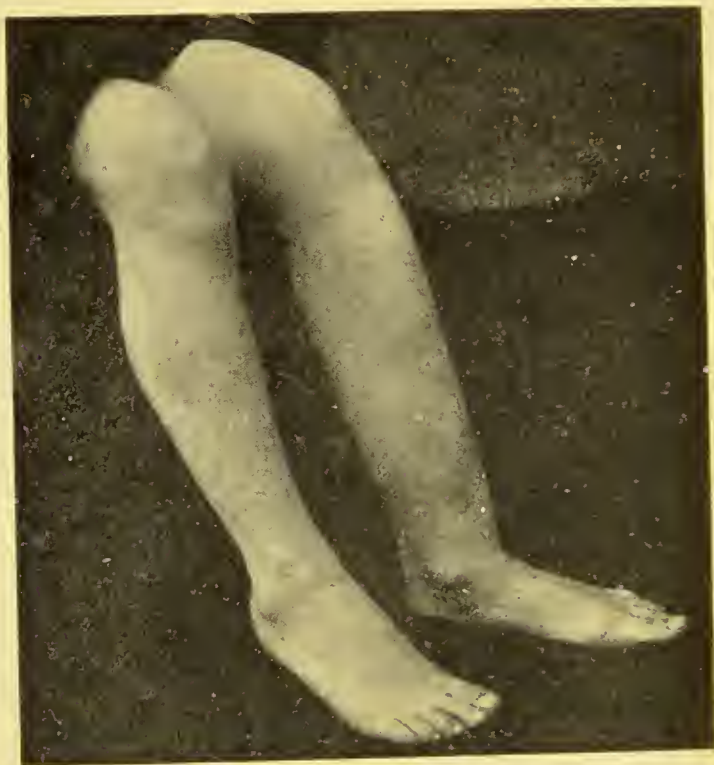


FIG. 247.—Sabre-blade Deformity of Left Tibia in Inherited Syphilis.
(From a photograph lent by Sir George T. Beatson.)

bone. The swelling may disappear entirely or may give place to a densely hard node. In some cases the gumma softens in the centre, the skin becomes adherent, thin, and red, and finally gives way. The opening in the skin persists as a sinus, or develops into a typical syphilitic ulcer with irregular, crescentic margins; in either case a probe reveals the presence of carious bone or of a sequestrum. The general health may be impaired as a result of superadded pyogenic infection, and the

absorption of toxins, and waxy degeneration in the viscera may ultimately be induced.

A *central gumma* in a long bone may not reveal its presence until it erupts through the shell and reaches the periosteal surface or invades an adjacent joint. Sometimes the first manifestation is a fracture of the bone produced by slight violence.

In radiograms the appearance of syphilitic bones is often characteristic. When there is hyperostosis and sclerosis, the shadow of the shaft of the bone is denser and broader than normal, and the contour is uneven or wavy. When there is a central gumma, the shadow is interrupted by a rounded clear area, like that of chondroma and myeloma.

Diagnosis. — The conditions most liable to be mistaken for syphilitic disease of bone are chronic staphylococcal osteomyelitis, tuberculosis, and sarcoma; and the diagnosis is to be made by the history and progress of the disease, the result of examination with the X-rays, and the effects of specific tests and medicines.

Treatment. — The general health is to be improved by open air, by nourishing food, and by the administration of cod-liver oil, iron, and arsenic. Anti-syphilitic remedies should be given a trial, and if they are administered before there is any destruction of tissue, the benefit derived from them is usually very decided. In certain cases, and particularly when there are destructive changes in the bone complicated with septic infection, specific remedies have little effect. In cases of persistent or relapsing gummatous disease with ulceration of skin, it is often necessary to remove the diseased soft parts with the



FIG. 248.—Gummatous Disease of Tibiæ in a boy æt. 10, the subject of an Inherited Syphilis. There is a small gummatous ulcer just above left wrist, and an unbroken gumma in region of right elbow.

sharp spoon and scissors, and to gouge or chisel away the unhealthy bone, on the same lines as in tuberculous disease. When hyperostosis and sclerosis of the bone is attended with severe pain which does not yield to blistering, the periosteum may be incised and the sclerosed bone perforated with a drill, gouge, or trephine.

Lesions of the Bones in Inherited Syphilis.—Syphilis affects the bones more frequently in the inherited than in the acquired form of the disease. The lesions in infancy—epiphysitis, bossing of the skull, and craniotabes—have been described in the chapter on inherited syphilis.

The lesions met with later correspond to those of the tertiary period of the acquired disease, but as they affect bones which are still actively growing, they may interfere with the increase of the bones in length. Gummatous disease may come and go over periods of many years, with the result that the external appearance and architectural arrangement of a long bone may be profoundly altered. In the tibia, for example, the bone may be flattened laterally so that the anterior edge is sharp and narrow; or the shaft may be thickened and lengthened and curved forwards—an appearance known as the “sabre-blade” deformity (Fig. 247).

Treatment is carried out on lines similar to those recommended in the acquired disease. In view of the comparative inefficacy of iodides in inherited syphilis, most benefit results from measures directed to improving the general health. When curving of the tibia causes disability in standing and walking, the bone may be straightened by a cuneiform resection.

Syphilitic dactylitis is met with chiefly in children. It may affect any of the fingers, toes, metacarpals, or metatarsals, but is commonest in the first phalanx of the index-finger or of the thumb. Several fingers and toes may be attacked at the same time or in succession. The lesion consists in a gummatous infiltration of the soft parts surrounding the phalanx, or may take the form of a gummatous osteomyelitis, or these conditions may be combined.

The segment of finger becomes the seat of a swelling, which is more evident on the dorsal aspect, and, according to the distribution and extent of the disease, it is acorn-shaped, fusiform, or cylindrical. It is firm and elastic, and but slightly painful or tender. The movements of the fingers are impaired, especially if the joints are involved. In its early stages the disease is amenable to anti-syphilitic treatment, and may recover completely.

If untreated, the degenerated gummatous tissue approaches the surface, the skin over it becomes thin and purple and gives way, often on the lateral aspect of the finger, forming a sinus. The disintegrated bone may crumble away and the debris escape in the discharge; the formation of a visible sequestrum is exceptional. Shortening and deformity of the finger follow when the bone is destroyed. The differential diagnosis from tuberculous dactylitis has been described with that disease. Chondroma of the phalanges is recognised by the hardness and definition of the tumour, and by the appearances seen with the X-rays.

HYDATID DISEASE

This rare disease results from the lodgment of the embryos of the *tænia echinococcus*, which are conveyed to the marrow by the blood-stream. In contrast to what is observed in hydatids of internal organs such as the liver, the cysts are small, usually about the size of a pin-head, and they are present in enormous numbers diffusely scattered throughout the marrow. The formation of brood capsules and of scolices is exceptional, and hooklets are rarely found. The parts of the skeleton most often affected are the articular ends of the long bones, the bodies of the vertebræ, and the pelvis.

As the cysts increase in number and in size, the framework of the bone is gradually absorbed, and there result excavations or cavities. The marrow and spongy bone first disappear, the compact tissue then becomes thin and perforated, and pathological fracture may result. The bone gradually becomes expanded, and the cysts may escape through perforations into the surrounding cellular tissue, and when thus freed from confinement may attain considerable dimensions. Suppuration from superadded pyogenic infection is a frequent complication, and it may be attended with extensive necrosis, and lead to disorganisation of the adjacent joint.

Clinical Features.—The patient complains, over a long period, of deep-seated pains. In superficial bones, such as the tibia, there is obvious enlargement, and it may be possible to recognise egg-shell crackling, or unequal consistence of the bone, which is hard in some parts, and doughy and elastic in others. The disease may pursue an indolent course during months or years until some complication occurs, such as suppuration or fracture. With the occurrence of suppuration the disease becomes more active, and abscesses may form in the overlying soft parts and in the adjacent joint. In the vertebral column,

hydatids give rise to angular deformity and paraplegia. In the pelvis, there is usually great enlargement of the bones, and when suppuration occurs it is apt to infect the hip-joint and to terminate fatally.

Examination with the X-rays shows the characteristic excavations of the bone caused by the cysts. The disease is liable to be mistaken for central tumour, gumma, tuberculosis, or abscess of bone.

The *treatment* consists in thorough eradication of the parasite by operation. The bone is laid open and scraped or resected according to the extent of the disease, and the raw surfaces swabbed with 1 per cent. formalin. In advanced cases complicated with spontaneous fracture or with suppuration, amputation affords the best chance of recovery.

The lesions in the bones resulting from *actinomycosis* and from *mycetoma* have been described with these diseases.

GENERAL DISEASES OF NUTRITION SPECIALLY AFFECTING THE BONES

These include rickets, scurvy-rickets, osteomalacia, osteitis deformans, fragilitas ossium, and certain lesions met with in diseases of the nervous system.

RICKETS

Rickets or rachitis is a constitutional disease associated with disturbance of nutrition, and attended with characteristic changes in the skeleton. The disease is most common and most severe among the children of the poorer classes in large cities, who are improperly fed and are brought up in unhealthy surroundings. There is evidence that the most important factors in the causation of rickets are ill-health of the mother during pregnancy, and the administration to the child after its birth of food which is defective in animal fat, proteids, and salts of lime, or which contains these in such a form that they are not readily assimilated. The occurrence of the disease is favoured, and its features are aggravated, by imperfect oxygenation of the blood as the result of a deficiency of fresh air and sunlight, want of exercise, and by other conditions which tend to lower the general health.

Pathological Anatomy.—The most striking feature is the softness (malacia) of the bones, due to excessive absorption of osseous tissue, and the formation of an imperfectly calcified

tissue at the various sites of ossification. The affected portions of the skeleton lose their rigidity, so that the bones bend under the weight of the body, the traction of muscles, and other mechanical forces.

The *periosteum* is thick and vascular, and when detached carries with it plates and spicules of soft porous bone. The new bone deposited may be so abundant that it forms a thick crust on the surface, and in the flat bones of the skull this may be heaped up in the form of bosses or ridges resembling those met with in inherited syphilis (Fig. 44).

In the epiphysial cartilages and at the ossifying junctions, all the processes concerned in ossification, excepting the deposition of lime salts, occur to an exaggerated degree. The cartilage of the epiphysial disc proliferates actively and irregularly, so that it becomes softer, thicker, and wider, and gives rise to a visible swelling, best seen at the lower end of the radius and lower end of the tibia, and at the costochondral junctions, where the series of beaded swellings is known as the "rickety rosary."

The ossifying zone is increased in depth; the marrow is abnormally vascular; and any new bone that is formed is imperfectly calcified. The result is that the affected bones may never attain their normal length, and they remain stunted throughout life as in rickety dwarfs (Fig. 249), or the shafts may grow unequally and come to deviate from their normal axes, as in knock-knee and bow-knee. Areas of overgrown cartilage may persist as islands surrounded by bone or marrow, and, according to Virchow, may subsequently become the starting-point of cartilaginous tumours.

These changes are well brought out in skiagrams; instead of the well-defined narrow line which represents the epiphysial cartilage, there is an ill-defined, blurred zone of considerable depth.

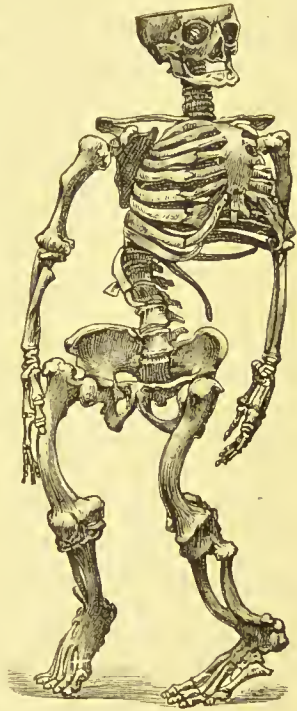


FIG. 249. — Skeleton of Rickety Dwarf, known as "Bowed Joseph," leader of the Meal Riots in Edinburgh, who died in 1780.

(Anatomical Museum, University of Edinburgh.)

The changes in the *marrow* are due to an excessive absorption of bone. In the shafts of the long bones the cortex becomes porous and yielding, and the spongy bone is rarefied or disappears; hence the bones readily bend or break under mechanical influences. When the disease is arrested, a process of repair sets in which often results in the bones becoming denser and heavier than normal. In the flat bones of the skull, the absorption may result in the entire disappearance of areas of bone, leaving a membrane which dimples like thin cardboard under the pressure of the finger—a condition known as *craniotabes*.

Changes in the Skeleton as a Whole.—The distribution and nature of the changes in the skeleton vary widely in different cases, being influenced by the period of onset, the severity and duration of the disease, and the conditions under which the child is placed.

In Children before they are able to walk.—The fontanelles and sutures of the *skull* remain open until the end of the second year or longer, and the frontal and parietal eminences are unduly prominent. There is sometimes hydrocephalus, and the whole head is characteristically enlarged and square. The jaws are altered so that while the upper jaw is contracted into the shape of a V, the lower jaw is square instead of rounded in outline, and the teeth do not oppose one another. In the *thorax*, the chief feature may be the beading at the costo-chondral junctions, principally of the fifth and sixth ribs, or its walls may be contracted, particularly if respiration is interfered with as a result of bronchial catarrh or adenoids. The contraction may take the form of a vertical groove on each side, or of a horizontal groove at the level of the upper end of the xiphi-sternum; when the sternum and cartilages form a projection in front, the deformity is known as “pigeon-breast.”

The *spine* may be curved backwards—*kyphosis*—throughout its whole extent or only in one part; or it may be curved to one side—*scoliosis*.

In the *limbs*, the prominent features are the deficient growth in length of the long bones, the enlargements at the epiphysial junctions, and the bending, and occasional greenstick fracture, of the shafts. The degree of enlargement of the epiphysial junctions is directly proportionate to the amount of movement to which the bone is subjected (John Thomson). The curves at this stage depend on the attitude of the child while sitting or being carried—for example, the arm bones become bent in children who paddle about the floor with the aid of their arms: and in a child who lies on its back with the lower limbs

everted, the weight of the limb may lead to curvature of the neck of the femur—coxa vara. The clavicle or humerus may sustain greenstick fracture from the child being lifted by the arms; the femur, by a fall. From the extreme laxity of the ligaments, the joints can be moved beyond the normal limits, and the child is often observed to twist its limbs into abnormal attitudes.

In Children who are able to walk.—In these children the most important deformities occur in the spine, pelvis, and lower extremities, and result for the most part from yielding of the softened bones under the weight of the body. Scoliosis is the usual type of spinal curvature, and in extreme cases it may lead to a pronounced form of hump-back. The pelvis may remain small (*justo-minor pelvis*), or it may be contracted in the sagittal plane (*flat pelvis*); when the bones are unusually soft, the acetabular portions are pushed inwards by the femora bearing the weight of the body, and the pelvis assumes the shape of a trefoil, as in the malacia of women. The shaft of the femur is curved forwards and outwards; the bones of the leg outwards, as in bow-leg, or forwards, or forwards and outwards just above the ankle. The deformities at the knee (*genu valgum*, *genu varum*, and *genu recurvatum*), and at the hip (*coxa vara*), will be described with Deformities.

Clinical Features.—Although rickets may be met with at or soon after birth, it is usually not until the child is three or four months old that the disease manifests itself, and sometimes not until the second year. The mother notices that the child perspires excessively during sleep, especially about the head, is restless and throws off the bed-clothes, is disinclined to be moved, and cries unless gently handled. Its muscles become soft and flabby, and it is liable to attacks of diarrhoea and of bronchial catarrh. Dentition is delayed, and the teeth are apt to appear in the wrong order. The child is late in learning to walk. On examination, there is no difficulty in recognising the changes in the skeleton that have already been described. The cranium is oftenest affected in infants; the spine, thorax, and arms, in those a little older; and the lower extremities in children in whom the disease has developed comparatively late. The abdomen is prominent, partly from flatulent distension of the bowels, partly from downward displacement of the liver, which is sometimes enlarged, and from weakness of the belly walls; it appears larger from contrast with the contracted chest. The spleen may be enlarged. The weakness of the muscles of the trunk and limbs may be so pronounced as to raise the suspicion of a lesion of the spinal cord; and there may be an

increased excitability of the central nervous system, shown by the occurrence of spasm of the larynx or of general convulsions. As a rule, however, the more evident the deformities of rickets the less prevalent the spasms.

Rickety children present little resistance to infective diseases, and readily succumb, especially to pulmonary and intestinal tuberculosis. The progress of the disease is slow and intermittent, and varies with the age of the child, its surroundings, and the treatment employed; it may pass off in a few weeks, or may drag on for months or even years.

The majority of rickety patients seen in surgical practice suffer from the deformities resulting from rickets rather than from the disease itself. The examination of a large series of children at different ages shows that the deformities become less and less frequent with each year. Those who recover may ultimately show no trace of rickets, and this is especially true of children who grow at the average rate; in those, however, in whom growth is retarded, especially from the fifth to the seventh year, the deformities are apt to become permanent. It may be noted that scoliosis of rickety origin has little tendency towards recovery.

Treatment.—The treatment of the disease consists in regulating the diet, improving the surroundings of the patient, and preventing deformity. In the first instance it is necessary to attend to the stomach and bowels. Fresh air and sunshine are recommended, with precautions against catching cold. A change to the seaside, and the use of salt-water baths, followed by massage, are of great value. Phosphorus in doses of 100th grain may be given dissolved in cod-liver oil, and preparations of iron and lime may be added with advantage. To avoid those postures which predispose to deformities, the child should lie as much as possible. In the well-to-do classes this is readily accomplished by the aid of a nurse and the use of a perambulator. In hospital out-patients the child is kept off its feet by the use of a light wooden splint applied to the outer aspect of each lower extremity, and extending from the pelvis to six inches beyond the sole.

When deformities are already present, the treatment depends upon whether or not there is any prospect of the bone straightening naturally. Under five years of age this may, as a rule, be confidently expected; the child should be kept off its feet, and the limbs bathed and massaged. In children of five or six and upwards, the prospect of natural straightening is a diminishing one, and it is more satisfactory to correct the

deformity by operation. In rickety curvature of the spine, the child should lie on a firm mattress, or, to allow of its being taken into the open air, upon a double Thomas' splint extending from the occiput to the heels; the muscles acting on the trunk should be braced up by massage and appropriate exercises.

Late Rickets, Malacia of Puberty, or Rachitis Adollescens is met with at any age from nine to seventeen, and is generally believed to be due to a recrudescence of rickets which had been present in childhood. The disease is not attended with any disturbance of the general health; the pathological changes are the same as in infantile rickets, but are for the most part confined to the ossifying junctions, especially those which are most active during adolescence, for example at the knee-joint. The patient is easily tired, complains of pain in the bones, and, unless care is taken, deformity is liable to ensue. There can be no doubt that adolescent rickets plays an important part in the production of the deformities which occur at or near puberty, especially genu valgum, genu varum, and coxa vara, and it may be indirectly concerned in the production of scoliosis and flat foot.

Scurvy-Rickets or Infantile Scurvy.—This disease, described by Barlow and Cheadle, is usually regarded as a combination of rickets and scurvy, although, according to Ashby, the hæmorrhagic element is the result of anæmia. It is met with in infants under two years who have been brought up upon sterilised or condensed milk and other proprietary foods, and is most common in the well-to-do classes. The hæmorrhages, which are so characteristic of the disease, are usually preceded for some weeks by a cachectic condition, with listlessness and debility and disinclination for movement; the child is anæmic, has a sallow, earthy tint, is short of breath on exertion, refuses food, and is exceedingly irritable. Very commonly he ceases to move one of his lower limbs—pseudo-paralysis—and screams if it is touched; a swelling is found over one of the bones, usually the femur, accompanied by exquisite tenderness; the skin is tense and shiny, and there may be some œdema. These symptoms are due to a sub-periosteal hæmorrhage, and associated with this there may be crepitus from separation of an epiphysis, very rarely from fracture of the shaft of the bone. X-ray photographs show enlargement of the bone, the periosteum being raised from the shaft and new bone formed in relation to it. Hæmorrhages also occur into the skin, presenting the appearance of bruises, into the orbit and conjunctiva, and from the gums and mucous membranes.

The *treatment* consists in correcting the errors in diet. The infant should have a wet-nurse or a plentiful supply of cow's milk in its natural state. Anti-scorbutics in the form of orange, lemon, or grape juice, and of potatoes bruised down in milk, may be given. Under this treatment marked improvement usually takes place within a few days, the hæmorrhages cease, and the extravasated blood is gradually absorbed. The rachitic element is treated on the lines already described, and the bone lesions on general principles.

Osteomalacia.—The term osteomalacia includes a group of conditions in which the bones of adults become soft and yielding, so that they are unduly liable to bend or break. The tendency is to regard rickets and osteomalacia as fundamentally the same, only as they affect the skeleton at different ages, they present anatomical and clinical features dependent upon the physical conditions at these ages.

The *osteomalacia of pregnant and puerperal women* is met with chiefly in women of the poorer classes who bear children under unhealthy conditions. It is more common in the parts of South Germany bordering on the Rhine and in certain parts of Italy, than in this country. While it may occur during a first pregnancy, it is oftener met with in multiparous women. It is usually confined to the pelvis and lumbar vertebræ, but in extreme cases may involve the entire skeleton.

In the progressive stage the marrow becomes very vascular, loses its fat, and is converted into a gelatinous tissue variously coloured with blood pigment derived from hæmorrhages, and these may result in the formation of cysts filled with brown or yellow fluid. The lime salts are absorbed, the bones lose their rigidity, and bend under the weight of the body or other mechanical influences. After death they are so soft that they may be cut with a knife or squeezed like a sponge. In extreme cases the shafts of the long bones come to resemble membranous tubes which may be bent or twisted in any direction.

The patient complains of shooting pains in the lower part of the back, weakness of the lower limbs, and inability to sit up. The bones are tender on pressure, and the knee jerks are usually increased. When the spinal column is affected, the vertebræ become compressed, and the patient may lose a foot or more in height within a few weeks. There may be a waddling gait from curving of the neck of the femur on both sides, and inability to flex the thigh and lift the foot from the ground. The pressure of the head of the femur on either side

causes the acetabular portions to project into the cavity of the pelvis. If recovery ensues, new bone replaces that which has been lost, the bones regain their rigidity, but the deformities persist.

The diagnosis is only difficult in the early stages of mild cases, in which the marked weakness of the lower extremities and exaggeration of the knee jerks may suggest a resemblance to certain diseases of the spinal cord. The bones do not give the usual dark shadow when examined with the Röntgen rays.

Measures directed towards improving the general health should be employed.

The administration of phosphorus dissolved in cod-liver oil is recommended. Improvement has been observed after subcutaneous injections of adrenalin, one c.c., every second day. Removal of the ovaries, as suggested by Fehling in 1886, has been followed by the relief of symptoms and arrest of the progress of the disease. For a description of the changes in the pelvis and their relation to pregnancy and parturition the student is referred to a text-book on Midwifery.



FIG. 250.—Changes in the Skull resulting from Ostitis Deformans.

(Anatomical Museum, University of Edinburgh.)

Neuropathic Forms of Osteomalacia.—In certain chronic diseases of the brain and cord, changes in the skeleton of the nature of osteomalacia may be met with. It is at present unknown why in certain cases the bones lose their lime salts and bend, while in others they become porous and brittle. The *senile form of osteomalacia* also is apparently of nerve origin.

Osteomalacia associated with New Growths in the Skeleton.—When *secondary cancer* is widely distributed throughout the skeleton, it is associated with softening of the bones, as a result of which they readily bend or break, and after death are easily cut with a knife. In the disease known as *multiple*

myeloma, the interior of the ribs, sternum, and bodies of the vertebræ is occupied by a reddish gelatinous pulp, the structure of which resembles sarcoma; the bones are reduced to a mere shell, and may break on the slightest pressure; the urine contains albumose, a substance resembling albumen, but coagulating at a comparatively low temperature (140° F.), and the coagulum is re-dissolved on boiling, and it is readily precipitated by hydrochloric acid (Bence-Jones).

Ostitis Deformans—Paget's Disease of Bone.—This rare disease was first described by Sir James Paget in 1877. In the early stages, the marrow is transformed into a vascular connective tissue; its bone-eating functions are exaggerated, and the framework of the bone becomes rarefied, so that it bends under pressure as in osteomalacia. In course of time, however, new bone is formed in great abundance both by the periosteum and by the marrow; it is at first devoid of lime salts, but later



FIG. 251.—Cadaver, illustrating the alterations in the Lower Limbs resulting from Ostitis Deformans.

becomes calcified, so that the bones regain their rigidity. This formation of new bone is much in excess of the normal, the bones become large and bulky, their surfaces rough and uneven, their texture sclerosed in parts, and the medullary canal is frequently obliterated. These changes are well brought out in X-ray photographs. The curving of the long bones, which is such a striking feature of the disease, may be associated with actual lengthening, and the changes are sometimes remarkably symmetrical (Fig. 251). The bones forming the cranium may be enormously thickened, the sutures are obliterated, the distinction into tables and diploë is lost, and, while the general texture is finely porous, there may be areas as dense as ivory (Fig. 250).

Clinical Features.—The disease is usually met with in persons over fifty years of age. It is insidious in its onset, and the patient's attention may be first attracted by the occurrence of vague pains in the back or limbs: by the

enlargement and bending of such bones as the tibia or femur; or by a gradual increase in size of the head, necessitating the wearing of larger hats. When the condition is fully developed, the attitude and general appearance are eminently characteristic. The height is diminished, and, owing to the curving of the lower limbs and spine, the arms appear unnaturally long; the head and upper part of the spine are bent forwards; the legs are held apart, slightly flexed at the knees, and are rotated out as well as curved; the whole appearance suggests that of one of the larger anthropoid apes. The muscles of the limbs may waste to such an extent as to leave the large, curved, misshapen bones covered only by the skin (Fig. 251). In the majority of cases the bones of the lower extremities are much earlier and more severely affected than those of the upper extremity, but the capacity of walking is usually maintained even in the presence of great deformity. In a case observed by Byrom Bramwell, the patient suffered from a succession of fractures.

The disease may last for an indefinite period, the general health remaining for long unaffected; the patient, however, finally succumbs to bronchitis or other intercurrent disease. In a considerable number of cases one of the bones becomes the seat of sarcoma.

Treatment is directed towards improving the general health, and to the relief of symptoms.

Osteomyelitis Fibrosa.—This disease, which was first described by Von Recklinghausen, presents many remarkable features. It is usually met with in children or adolescents, and there are grounds for regarding it as a juvenile form of Paget's disease. It may affect a single bone or be widely diffused in the skeleton; on making a longitudinal section, it is found that the marrow of the shaft is replaced by a vascular fibrous tissue, which encroaches on the bony framework, whereby this is replaced and reduced to slender proportions. The fibrous tissue frequently shows diffuse infiltration by giant cells like those of a myeloma; but there is an absence of malignant tendencies, and it does not invade the soft parts or give rise to metastases. The formation of cysts in the marrow is often a prominent feature, and because of this it has been named *osteomyelitis fibrosa cystica*. The cysts are devoid of epithelial lining, contain a straw-coloured fluid, and apparently arise from liquefaction of the altered marrow. It would appear that most of the recorded cases of cyst of bone owe their origin to this disease. The finding of giant cells, and

occasionally of islands of cartilage, in the wall of the cyst led to the erroneous view that the cyst resulted from the liquefaction of a sarcomatous or cartilaginous tumour.

The onset of the disease is insidious, and there may be nothing more than the complaint of vague pains before there is any recognisable alteration in the bone affected. Most frequently the first visible manifestation is the occurrence of a



FIG. 252.—Osteomyelitis Fibrosa affecting Femora in a man *et.* 19.
The curving of the bones is due to multiple fractures.

fracture from some slight cause. Less commonly the bone gradually becomes curved or enlarged, and the enlargement may assume a spindle or globular form, or may be diffused throughout the shaft; as a rule, it does not encroach upon the epiphysis. The flat bones of the skull may be involved, not uniformly as in Paget's disease in the adult, but in the form of asymmetrical bosses, which cause great disfigurement. Patches of brown pigmentation of the skin of the head and trunk, not

unlike those seen in generalised neuro-fibromatosis, are also met with.

The diagnosis from other chronic affections of bone is difficult and can scarcely be made without skiagrams. These show that the contour and architecture of the bone are greatly altered; there is a localised or a diffuse increase of girth; the surface of the bone is uneven, and in the interior there are clear areas from which the osseous tissue has entirely disappeared. These clear areas, from their even contour, sharp definition, and translucency, can be recognised as cysts.

If fracture occurs, there is often considerable comminution, and although union may result, it is long delayed and attended with considerable deformity and shortening.

The treatment is chiefly directed to protecting the affected bone from injury. This may be accomplished by the wearing of a stiff leather cylinder, which laces up the limb. In cases in which the disease has been confined to one bone, benefit has followed upon operative interference, which consists in opening up the marrow and scraping out the diseased tissue.

Neuropathic Atrophy of Bone.—The conditions included under this heading occur in association with diseases of the nervous system, but it is difficult to ascertain how far the changes in the skeleton are due to altered trophic nerve influence, and how far they are the result of vaso-motor disturbances.

Among the clinical forms of neuropathic atrophy, most importance attaches to the fragility of the bones met with in general paralysis of the insane, locomotor ataxia, and other chronic diseases of the brain and spinal cord. The bones become porous and brittle, with an excess of fatty matter, so that they are liable to be fractured by forces which would be insufficient to break a healthy bone. In *locomotor ataxia* the fractures affect especially the bones of the lower extremities, and may occur before there are any definite nerve symptoms, but they are more often met with in the ataxic stage, when the abrupt and uncontrolled movements of the limbs play a considerable part in their causation. They may be unattended with pain, and may fail to unite; when repair does take place, it is sometimes attended with an excessive formation of callus. Joint lesions of the nature of Charcot's disease may occur simultaneously with the alterations in the bones. In *syringomyelia* pathological fracture is not so frequent as in locomotor ataxia; it is more likely to occur in the bones of the upper extremity, and especially in the humerus. In some cases of *epilepsy* the bones may be so brittle that they break when

the patient falls in a fit, and the fracture is usually comminuted.

In the early stages of these affections of the nervous system the bones present no histological or chemical alterations, and the X-ray shadow does not differ from the normal. It is maintained, therefore, that the disposition to fracture does not depend upon a fragility of the bone, but on the loss of the muscular sense and of common sensation in the bones, as a result of which there is an inability properly to throw the muscles into action and dispose the limbs so as to place them under the most favourable conditions to meet external violence.

Osteogenesis Imperfecta, Fragilitas Ossium, or Congenital Osteopsathyrosis.—These terms are used to describe a condition formerly known as foetal rickets, in which an undue fragility of the bones dates from intra-uterine life. It may occur in several members of the same family. In severe cases, intra-uterine fractures occur, and during the birth of the child fresh fractures are almost sure to be produced, so that at birth there is generally a combination of recent fractures and old fractures united and partly united, with bendings and thickenings of the bones. Large areas of the cranial vault may remain membranous for a considerable period.

After birth the predisposition to fracture continues, the bones are easily broken, the fractures are attended with little or no pain, the crepitus is soft, and although union may take place, it may be much delayed and be attended with excess of callus. Cases have been observed in which a child has sustained over a hundred fractures.

The bones show a feeble shadow with the X-rays, and appear thin and atrophied; the medullary canal is increased at the expense of the cortex. The cause of the imperfect bone formation is unknown, but it would appear to depend upon a general disease affecting nutrition.

In young infants in whom multiple fractures occur the prognosis as to life is unfavourable, and no satisfactory treatment of the disease has been formulated. In the event of survival, the tendency to fracture gradually disappears.

Hypertrophic Pulmonary Osteo-Arthropathy.—This condition, which was described by Marie in 1890, is nearly always secondary to disease in the chest, such as chronic phthisis, empyema, bronchiectasis, or sarcoma of the lung. There is symmetrical enlargement and deformity of the hands and feet: the shafts of the bones are thickened, and the soft tissues of the terminal segments of the digits hypertrophied. The

fingers come to resemble drum-sticks, and the thumbs the clapper of a bell. The nails are convex, and incurved at their free ends, suggesting a resemblance to the beak of a parrot. There is also enlargement of the lower ends of the bones of the forearm and leg, and effusions into the wrist and ankle-joints. Skiagrams of the hands and feet show a deposit of new bone along the shafts of the phalanges.

TUMOURS OF BONE

New growths which originate in the skeleton are spoken of as *primary tumours*; those which invade the bones, either by metastasis from other parts of the body or by direct spread from adjacent tissues, as *secondary*. A tumour of bone may grow from the periosteum, the marrow, or the epiphysial cartilage.

Primary tumours are always of the connective-tissue type, and are usually solitary, although certain forms, such as chondroma, osteoma, myeloma, and sarcoma are sometimes multiple from the outset.

Periosteal tumours are at first situated on one side of the bone, but as they grow may come to surround it completely. Innocent periosteal tumours retain the outer fibrous layer of the periosteum as a capsule and exert pressure atrophy on the bone. Malignant tumours tend to perforate the periosteal capsule and eat into the subjacent bone.

Central or medullary tumours as they grow outwards cause absorption of the bone; the periosteum, however, forms successive layers which are in their turn absorbed, so that the bone as a whole is increased in girth, and is apparently "expanded" by the growth in its interior. Whether or not a central tumour invades the surrounding soft parts depends on the rapidity of its growth, that is, on its malignancy, and on the activity of the periosteum in forming new bone.

While it is frequently observed that tumours of bone follow upon injury, the causal connection between the injury and the development of the tumour is not established; it may be that the trauma merely hastens the growth of an already existing tumour, or that it excites growth in embryonic residues resulting from some irregularity in development.

Primary Tumours—Osteoma.—When it projects from the surface of a bone, this variety of tumour is called an *exostosis*. When derived directly from the tissues of the periosteum, for example in the skull, it is described as a *membranous exostosis*—and as it is usually dense and compact like ivory, the term

ivory exostosis is sometimes employed. When derived from hyaline cartilage—for example, at the ends of the long bones—it is known as a *cartilaginous exostosis*, and because of its spongy structure it is also described as a *cancellous* or *spongy exostosis*. This is invested with a cap of cartilage from which it continues to grow until the skeleton attains maturity.

An exostosis forms a rounded or mushroom-shaped tumour of limited size, which may be either sessile or pedunculated, and its free surface is smooth or nodulated. A cartilaginous exostosis in the vicinity of a joint may be invested with a synovial sac or bursa—the so-called *exostosis bursata*. The bursa may be derived from the synovial membrane of the adjacent joint with which its cavity sometimes communicates, or it may be of adventitious origin; when it is the seat of bursitis and becomes distended with fluid, it may prevent the recognition of the underlying exostosis.

Clinically, the osteoma forms a hard, indolent tumour attached to a bone. Unless it presses injuriously on adjacent structures, its discovery is usually accidental. The symptoms to which it gives rise vary with its situation. In the vicinity of a joint it may interfere with movement; at the inner side of the knee it may knock against the other limb, or incapacitate the patient from riding. When growing from the dorsum of the terminal phalanx of the great toe—*subungual exostosis*—it displaces the nail, and may project through its matrix at the point of the toe, while the soft parts over it may be ulcerated from pressure (Fig. 98). When it presses on nerves, it causes pains, cramps, and other nerve symptoms. In the orbit it displaces the eyeball; in the nasal fossæ and in the external auditory meatus it causes obstruction, which may be attended with ulceration and discharge. In the skull it may project from the outer table, forming a smooth rounded swelling, or it may project from the inner table and press upon the brain.

The diagnosis is to be made by the slow growth of the tumour, its hardness, and by the shadow which it presents with the X-rays.

An osteoma which does not cause symptoms may be left alone, as it ceases to grow when the skeleton is mature. If causing symptoms, it is removed by dividing the neck or base of the tumour with a chisel, care being taken to remove the whole of the overlying cartilage. The dense varieties met with in the bones of the skull present greater difficulties; if it is necessary to remove them, the base or neck of the tumour is perforated in many directions with highly tempered drills

rotated by some form of engine, and the division of the bone completed with the chisel.

Multiple exostoses are met with in childhood and youth, and are really chondromata which have undergone ossification. They occur chiefly in the vicinity of the most active epiphyses—that is, in the region of the knee, shoulder, and wrist; are often symmetrical, and vary greatly in size. They originate from the ossifying junctions of the long bones, and as the shaft increases in length may come to lie at some distance from the epiphysis, and they usually cease growing when the skeleton reaches maturity. They may also grow from flat bones, such as the scapula and pelvis. When growing from a vertebra, the tumour may project into the spinal canal and press on the cord. The anatomical characters of exostoses are well brought out by the X-rays.

From the fact that the condition is usually inherited, and that there is often an arrest of growth and curvature of several of the long bones, it is assumed that there is a widespread disturbance in the development of the skeleton dating from intra-uterine life. There is no indication for surgical interference, but if any particular tumour is a source of inconvenience it is easily removed by chiselling through its neck. The co-existence of pure chondroma with multiple exostoses is not infrequent, and, as the former tends to take on active growth and give rise to metastases, it should be promptly and radically removed.

Diffuse Osteoma, Leontiasis Ossea.—This rare affection was



FIG. 253.—Multiple Exostoses of both limbs.
(Photograph lent by Sir George T. Beatson.)

described by Virchow, and named *leontiasis ossea* because of the peculiar disfigurement to which it gives rise. It usually commences in young adults as a diffuse overgrowth of the upper jaws, which are enlarged in all directions and project as prominent bosses on the face, and the nasal fossæ and the maxillary and frontal sinuses become filled up with bone, which encroaches also on the orbital cavities. In addition to the hideous deformity, the patient suffers from blocking of the nose, loss of smell, and protrusion of the eyes, sometimes followed by loss of sight. The condition is liable to spread to the malar and frontal bones, the vault of the skull, and to the lower jaw; the base of the skull is not affected. The disease is of slow progress and may become arrested; life may be prolonged for many years, or may be terminated by brain troubles or other intercurrent affections. In certain cases it is possible to remove some of the more disfiguring of the bony masses.

A less aggressive form, confined to the upper jaw on one side, is sometimes met with, and, in a case of this variety under our own observation, the disfigurement, which was the only subject of complaint, was removed, after reflecting the soft parts, by paring away the excess of bone with a chisel.

A remarkable form of *unilateral hypertrophy and diffuse osteoma of the skull*, following very accurately the distribution of the fifth nerve, has been described by Jonathan Hutchinson and Alexis Thomson.

Chondroma. — Cartilaginous tumours grow from the long bones and from the scapula, ilium, ribs, or jaws. They usually project from the periosteal surface of the bone, and may attain an enormous size; sometimes they grow in the interior of a bone, the so-called *enchondroma*.

The hyaline cartilage composing the tumour frequently undergoes myxomatous degeneration, resulting in the formation of a glairy, semi-fluid jelly, and if this change takes place throughout the tumour it comes to resemble a cyst. On the other hand, the cartilage may undergo calcification or ossification. The most important transition of all is that into sarcoma, the so-called *malignant chondroma* or *chondro-sarcoma*, which is associated with rapid increase in size, and parts of the tumour may be carried off in the blood-stream and give rise to secondary growths, especially in the lungs.

The chondroma is met with as a slowly growing tumour, which is specially common in the bones of the hand, often in a multiple form (Figs. 254, 255). The surface is smooth or lobulated, and in consistence the tumour may be dense and

elastic like normal cartilage, or may present areas of softening, or of bony hardness. The skin moves freely over it, except in relation to the bones of the fingers, where it may become adherent and ulcerate, simulating the appearance of a malignant tumour. Large tumours growing from the bones of the extremities may implicate the main vessels and nerves (Fig. 257), either surrounding them, or pressing on them.

Portions of a chondroma, which have undergone calcification or ossification, throw a dark shadow with the X-rays.

Treatment.—It is necessary to remove the whole tumour, and in chondromata growing from the surface of the bone, especially if they are pedunculated, this is comparatively easy. When an entire bone, such as the scapula or lower jaw, is involved, it is better to excise the bone, or at least the part of it which bears the tumour. In the case of central tumours the shell of bone is to be removed over an area sufficient to allow of the enucleation of the tumour, or the affected portion of bone is resected. Should there be evidence of malignancy, such as increased rate of growth, amputation is called for.

In multiple chondromata of the hand in young subjects (Fig. 254), it was formerly the custom to amputate the limb; an attempt should be made to avoid this by shelling out the larger tumours individually, and persevering with the application of the X-rays to inhibit the growth of the smaller tumours.

Chondromata springing from the pelvic bones usually arise in the region of the sacro-iliac joint; they project into the cavity of the pelvis and press on the bladder and rectum, on the sciatic and obturator nerves; sometimes also on the iliac veins, causing œdema of the legs. They are liable to take on malignant characters, and rarely lend themselves to complete removal by operation.

The chondromata which undergo ossification concurrently with the skeleton have been described with the osteomata.

Fibroma is met with chiefly as a periosteal growth in

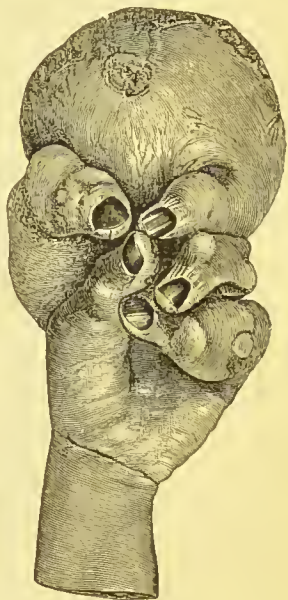


FIG. 254.—Multiple Chondromata of Bones of Hand.
(Anatomical Museum, University of Edinburgh.)

relation to the mouth and pharynx, the *simple epulis* of the alveolar margin and the *naso-pharyngeal polypus* being the most common examples. They will be described with the special regions in which they occur.

Myxoma, *lipoma*, and *angioma* of bone are all very rare.

Myeloma.—The myeloid tumour, which is sometimes classified with the sarcomata, contains as its chief elements large giant cells, like those normally present in the marrow. On



FIG. 255.—Multiple Chondromata in hand of boy æt. 8 (cf. Fig. 256).

section these tumours present a brownish-red or chocolate colour, and, being very vascular, are liable to hæmorrhages, to pigmentation, and to the formation of blood cysts. Sometimes the arterial vessels are so dilated as to impart to the tumour an aneurysmal pulsation and bruit. The enlargement or "expansion" of the bone may result in the cortex being represented by a thin shell of bone, which may crackle on pressure—parchment or egg-shell crackling.

The myeloma is most often met with between the ages of twenty-five and forty in the upper end of the tibia or lower end of the femur (Fig. 258). It grows slowly and causes

little pain, and may long escape recognition unless an examination is made with the X-rays. The shadow shows a clear area near the end of the bone, not unlike a cyst, but the boundaries are not so clearly marked. The myeloma is to be diagnosed from other lesions met with in the ends of long bones, such as tubercle, syphilis, Brodie's abscess, chondroma, and osteomyelitis fibrosa with cyst formation. Although these tumours some-



FIG. 256.—Radiogram of Multiple Chondromata, from same case as Fig. 255.
Note large tumour on index, and smaller growths in phalanges of other fingers.

times give rise to secondary growths presenting a similar giant-celled structure, they are, as a rule, innocent, and should be treated as such. In early cases the cortex is divided to give free access to the tumour tissue, which is scraped out with the spoon; in more advanced cases the segment of bone is resected and a portion of the tibia or fibula covered with periosteum from the other limb inserted into the gap.

The coexistence of diffuse myelomatosis of the skeleton and albumosuria (Bence-Jones) is referred to on p. 666. Myelomata occur in the jaws, taking origin in the marrow or from the

periosteum of the alveolar process, and are described elsewhere.

Sarcomata and **endotheliomata** are the commonest tumours of bone, and present wide variations in structure and in clinical features. Structurally, two main groups may be differentiated :

- (1) the soft, rapidly growing cellular tumours, and
- (2) those containing fully formed fibrous tissue, cartilage, or bone.

(1) The *soft cellular tumours* are composed mainly of spindle or round cells; they grow from the marrow of the spongy ends or from the periosteum of the long bones, the diploë of the skull, the pelvis, vertebræ, and jaws. As they grow they may cause little alteration in the contour of the bone, but they eat away its framework and replace it, so that the continuity of the bone is maintained only by tumour tissue, and pathological fracture is a frequent result. The small round-celled sarcomata are among the most malignant tumours of bone, growing with great rapidity, and at an early stage giving rise to secondary growths.



FIG. 257.—Chondroma of Femur.
The femoral vessels pass through the substance of the tumour, and the sciatic nerve is adherent to its surface.

(2) The second group includes the *fibro-*, *osteo-*, and *chondro-sarcomata*, and combinations of these; in all of them fully formed tissue predominates over the cellular elements. They grow chiefly from the deeper layer of the periosteum, and at first form a projection on the surface, but later tend to surround the bone (Fig. 262), and to invade its interior, filling up the marrow spaces with a white, bone-like substance; in the flat

bones of the skull they may traverse the diploë and erupt on the inner table. The tumour tissue next the bone consists of a dense, white, homogeneous material, from which there radiate into the softer parts of the tumour, spicules, needles, and plates of a bone-like material, often exhibiting a fan-like arrangement. The peripheral portion consists of soft sarcomatous tissue, which invades the over-lying soft parts; the articular cartilage, on the other hand, long resists destruction. These ossifying sarcomata are met with most often in the femur and tibia, less frequently in the humerus, skull, pelvis, and jaws. In the long bones they may grow from the shaft, while the chondrosarcomata more often originate at the extremities. Sometimes they are multiple, several tumours appearing simultaneously or one after another. Secondary growths are met with chiefly in the lungs, metastasis taking place by way of the veins.

Clinical Features.—Sarcomata are usually met with before the age of thirty, and are comparatively common in children. Males suffer oftener than females in the proportion of two to one.

In the case of a *periosteal sarcoma* the presence of a swelling is usually the first symptom; the tumour is fusiform, firm, and regular in outline, and when it occurs near the end of a long bone the limb frequently assumes a characteristic “leg of mutton” shape (Fig. 263). The surface may be uniform or bossed, the consistence varies at different parts, and the swelling gradually tapers off as it extends along the shaft. On firm pressure, fine crepitation may be felt from crushing of the delicate framework of new bone.

In *central sarcoma* pain is the first symptom, and it is usually constant, dull, and aching; is not obviously increased by use of the limb, but is often worse at night. Swelling occurs late, and is due to expansion of the bone; it is fusiform or globular, and is at first densely hard, but in time there may be parchment-like or egg-shell crackling from yielding of the thin shell. The swelling may pulsate, and a bruit may be heard over it. In advanced cases it may be impossible to



FIG. 258.—Myeloma of Lower End of Femur. The patient had formerly sustained a fracture of the shaft.

differentiate between a periosteal and a central tumour, either anatomically or clinically.

Pathological fracture is more common in the central tumours, and sometimes is the first sign that calls attention to the condition. Consolidation rarely takes place, although there is often an attempt at union by the formation of cartilaginous callus.

The soft parts over the tumour may for a long time preserve their normal appearance; or they may become œdematous, and the subcutaneous venous network be evident through the skin. Elevation of the temperature of the skin over the tumour, which may amount to two degrees or more, is a point of diagnostic significance.

The adjacent joint usually remains intact, although its movements may be impaired by the mere bulk of the tumour or by effusion into the cavity.

Enlargement of the neighbouring lymphatic glands does not necessarily imply that they have become infected with sarcoma, for the enlargement may disappear after removal of the primary growth; actual infection of the glands, however, does sometimes occur.

To obtain a reasonable prospect of cure by operation, the *diagnosis* must be made at an early stage of the disease. Reliance is to be placed on information gained by examination with the X-rays. In periosteal sarcoma, the periosteum at the edge of the tumour may be seen to be lifted up

and to be gradually lost in the soft parts; under the periosteum and in the substance of the tumour fine trabeculae or spicules of bone can usually be seen, while the cortex of the shaft appears roughened. In central sarcoma there is evidence of absorption of bone in the interior, and in the later stages it may be entirely replaced by tumour tissue, only a thin film of the cortex remaining.



FIG. 259.—The Femur of a boy æt. 12, showing the Bony Shell of a large Cyst-like Cavity which communicates with the interior of the bone. The original tumour was probably a sarcoma.

(The specimen, which is in the Anatomical Museum, University of Edinburgh, is figured in Syme's *Principles of Surgery*.)

In difficult cases the final appeal is to exploratory incision and microscopical examination of a portion of the tumour; this should not be done as a preliminary operation, as it is liable to disseminate the disease. It should be done when the major operation has been arranged for, the surgeon waiting until the examination is made.

It is to be borne in mind that when a fracture of a long bone takes place in a young adult from comparatively slight violence, sarcoma of the bone should be suspected and an X-ray examination made.

Skiagraphy is not only of assistance in differentiating new growths from other diseases of bone, but may also yield information as to the situation and nature of the tumour, which may have important bearings on treatment.

The *prognosis* varies widely. In general, it may be said that periosteal tumours are less favourable than central ones, because they are more liable to give rise to metastases. Our own experience is that the majority of cases of sarcoma of bone succumb within one or two years to secondary growths in the lungs or elsewhere. According to König, the permanent cures amount only to 18 per cent.

Treatment.—When one of the bones of a limb is involved, the usual practice has been to perform amputation well above the growth, and this is still recommended as a routine procedure. There are reasons, however, which may be urged against its continuance. High amputation is unnecessary in the more benign sarcomata, and in the more malignant forms is usually unavailing to prevent a fatal issue either from local recurrence or from metastases in the lungs or elsewhere. Following the lead of Mikulicz, a considerable number of permanent cures have been obtained by resecting the portion of bone which is the seat of the tumour, and substituting for it a corresponding portion from the tibia or fibula of the other limb. When resection is impracticable, a subcapsular enucleation is performed, followed by exposure to the X-rays or to radium. Recourse may also be had to the injection of Coley's fluid.



FIG. 260.—Periosteal Sarcoma of Humerus.
(Anatomical Museum, University of Edinburgh.)

Pulsating Hæmatoma or Aneurysm of Bone.—A limited number of these are cavernous tumours dating from a congenital angioma. The majority would appear to be the result of changes in a sarcoma, endothelioma, or myeloma. The tumour tissue largely disappears, while the vessels and vascular spaces undergo a remarkable development. The tumour may come to be represented by one large blood-containing space communicating with the arteries of the limb; the



FIG. 261.—Central Sarcoma of Lower End of Femur,
invading the knee-joint.

(Museum of Royal College of Surgeons,
Edinburgh.)

walls of the space consist of the remains of the original tumour, plus a shell of bone of varying thickness. The most common seats of the condition are the lower end of the femur, the upper end of the tibia, and the bones of the pelvis.

The *clinical features* are those of a pulsating tumour of slow development, and as in true aneurysm, pulsation and bruit disappear on compression of the main artery. The origin of the tumour from bone may be revealed by the

presence of egg-shell crackling, and by examination with the X-rays.

If the condition is believed to be innocent, the treatment is the same as for aneurysm—preferably by ligation of the main artery; if malignant, it is the same as for sarcoma.

Secondary Tumours of Bone.—These include all varieties of tumour which are capable of occurring by metastasis, and those which spread to the bone by direct continuity.

Metastatic Tumours.—*Secondary cancer* is a comparatively common disease. Its characters depend on the nature of the primary growth from which it arises. The soft forms grow rapidly, and eat away the bone. In slowly growing forms there may be considerable formation of imperfectly organised bone, often deficient in lime salts; this condition may be widely diffused throughout the skeleton, and as it is associated with softening and bending of the bones, it is known as *cancerous osteomalacia*. Secondary cancer of bone is attended with pain, or it suddenly attracts notice by the occurrence of pathological fracture—as, for example, in the shaft of the femur or humerus. In the vertebræ, it is attended with a painful form of paraplegia, which may involve the lower, or all four extremities.

On the other hand, the disease may show itself clinically as a tumour of bone, which may be of considerable size, and may be mistaken for a sarcoma, unless the existence of the original cancer is discovered.

The cancers most liable to give rise to metastasis in bone are those of the breast, liver, uterus, prostate, and intestine; hypernephroma of the kidney may also give rise to metastases in bone.

Secondary tumours derived from the thyroid gland require special mention, because they are peculiar in that neither the



FIG. 262.—Osseous Shell of Osteo-Sarcoma of Upper Third of Femur, after maceration.

primary growth in the thyroid nor the secondary growth in the bones are necessarily malignant. They are therefore amenable to operative treatment.

Secondary sarcoma, whether derived from a primary growth in the bone or in the soft parts, is much rarer than secondary cancer. Its removal by operation is usually impossible.

Cancer of Bone resulting from Direct Extension from adjacent Soft Parts.—In this group the bone is involved by the spread of the cancer in the same way as any other tissue. There are two clinical types. The first is met within relation to *epitheliomata of mucous surfaces*—for example, the palate, gums, antrum, frontal sinus, auditory meatus, or middle ear. They will be described under these



FIG. 263.— Periosteal Sarcoma of Femur in a young subject.

special regions. The second is met with in relation to *epithelioma occurring in a sinus*, the sequel of suppurative osteomyelitis or compound fracture or tuberculous disease. The patient has usually had a discharging sinus for a great number of years. The epithelioma originates at the skin orifice of the sinus, and spreads down to the bone and into its interior (Fig. 263A).



FIG. 263A.—Epitheliomatous Ulcer of Leg with direct extension to Tibia.

(Lord Lister's specimen. Anatomical Museum, University of Edinburgh.)

Inside the bone the progress of the cancer is resisted by sclerosis and obliteration of the medullary canal, but although its progress is slow, the infiltration of the bone is often more extensive than would appear externally. It is recognised clinically by the characteristic epitheliomatous growth in the sinus and its vicinity, and by the offensive nature of the discharge. A similar epithelioma may arise in connection with a chronic ulcer of the leg. The cancer may infect the femoral lymphatic glands. The operative treatment is influenced by the extent of the disease in the soft parts overlying the bone, and consists in wide removal of the diseased tissues, or in amputation.

Cysts of Bone.—With the exception of hydatid cysts, cysts in the interior of bone are the result of the liquefaction of such tumours as chondroma, myeloma, or sarcoma, or more commonly attend upon such chronic disease of the marrow as osteomyelitis fibrosa.

CHAPTER XXIX

DISEASES OF JOINTS

Definition of terms—Ankylosis: *Varieties*. DISEASES: Errors of development—Bacterial diseases: *Pyogenic*; *Tuberculous*; *Syphilitic*; *Acute rheumatism*—Diseases associated with certain constitutional conditions: *Gout*; *Chronic articular rheumatism*; *Arthritis deformans*; *Hæmophilia*—Diseases associated with affections of the nervous system: *Neuro-arthropathics*; *Charcot's disease*—Hysterical or mimetic affections of joints—Tumours and cysts—Loose bodies in joints.

Definition of Terms.—The term *synovitis* is applied to any inflammatory condition which affects the synovial membrane of a joint. It is usually associated with effusion of fluid into the joint, and this may be serous, sero-fibrinous, or purulent. As the term *synovitis* merely refers to the tissue involved in the inflammation, it should always be used with an adjective—such as *gouty*, *gonorrhœal*, or *tuberculous*—which indicates its pathological nature.

The terms *hydrops*, *hydrarthrosis*, and *chronic serous synovitis* are synonymous, and are employed when a serous effusion into the joint is the prominent clinical feature. *Hydrops* may occur apart from disease—for example, in the knee-joint, from repeated sprains—but is met with chiefly in the chronic and intermittent forms of *synovitis* which result from *gonorrhœa*, *tuberculosis*, *syphilis*, *arthritis deformans*, or *arthropathies* of nerve origin. It may occur also when there is a loose body in a joint.

Arthritis is the term applied when not only the synovial membrane but the articular surfaces, and it may be also the ends of the bones, are involved in the disease.

As in speaking of *synovitis*, so in using the term *arthritis* it is necessary to prefix a qualifying adjective which indicates its nature. According to its etiology, *arthritis* may or may not be attended with effusion into the joint. When effusion is present,

it may be serous, as in arthritis deformans, or sero-fibrinous or purulent, as in certain forms of pyogenic and tuberculous arthritis. Wasting of the muscles in the vicinity of the joint is a constant accompaniment of arthritis; it affects especially the extensor muscles, and the muscles do not show the reaction of degeneration. On account of the involvement of the articular surfaces, arthritis is apt to be followed by ankylosis.

The term *empyema* is sometimes employed to indicate that the cavity of the joint contains pus. It is observed chiefly in chronic suppurative disease of pyogenic or tuberculous origin, and is usually attended with the formation of abscesses outside the joint.

Ulceration of cartilage and caries of the articular surfaces are common accompaniments of the more serious and progressive forms of joint disease, especially those of bacterial origin. The destruction of cartilage may be secondary to disease of the synovial membrane or of the subjacent bone. When the disease begins in the synovial membrane, the latter spreads over the articular surface, fuses with the cartilage and eats into it, causing defects or holes which are spoken of as ulcers. When the disease begins in the bone, the marrow is converted into granulation tissue, and this eats into the cartilage and separates it from the bone. Following on the destruction of the cartilage, the articular surface of the bone undergoes disintegration, this condition being spoken of as *caries of the articular surface*. The occurrence of ulceration of cartilage and of articular caries is attended with rigidity of the joint from involuntary muscular contraction, with wasting of muscles, and with starting pains. These *starting pains* are the result of sudden involuntary movements of the joint, and they occur most frequently as the patient is dropping off to sleep. The muscles becoming relaxed, the sensitive ulcerated surfaces come to jar on one another, this causes sudden reflex contraction of the muscles, and the resulting movement being attended with severe pain, wakens the patient with a start. Advanced articular caries is usually associated with some abnormal attitude and with shortening of the limb. It may be possible to feel the bony surfaces grate upon one another. When all the constituent elements of a joint are damaged or destroyed, it is said to be *disorganised*. Should recovery take place, repair is usually attended with union of the opposing articular surfaces either by fibrous tissue or by bone.

Conditions of Impaired Mobility of Joints.—*Rigidity* is the fixation of a joint by the involuntary contraction of muscles,

and is of value as a sign of disease in deep-seated joints, such as the hip. It is sometimes called false ankylosis, because it disappears under anæsthesia.

Contracture is the term applied when the fixation is due to permanent shortening of the soft parts around the joint—muscles, tendons, ligaments, fasciæ, or skin. As the structures on the flexor aspect are more liable to undergo such shortening, contracture is nearly always associated with flexion. Contracture may result from disease of the joint, or from conditions outside it—for example, disease in one of the adjacent bones, or lesions of the nerves.

Ankylosis is the term applied when impaired mobility results from changes involving the articular surfaces. It is frequently combined with contracture and with thickening and induration of the ligaments. Three anatomical varieties of ankylosis are recognised—(a) The *fibrous*, in which there are adhesions between the opposing surfaces, which may be in the form of loose isolated bands of fibrous tissue, or may bind the bones so closely together as to obliterate the cavity of the joint. The resulting stiffness, therefore, varies from a mere restriction of the normal range of movement, up to a close union of the bones which prevents movement. Fibrous ankylosis may follow upon injury, especially dislocation or fracture implicating a joint, or it may result from any form of arthritis. (b) *Cartilaginous ankylosis* implies the fusion of two apposed cartilaginous surfaces. It is best seen between the patella and the trochlear surface of the femur in certain forms of tuberculous disease of the knee. The fusion of the cartilaginous surfaces is preceded by the spreading of a vascular connective tissue, derived from the synovial membrane, over the articular cartilage. Clinically, it is associated with absolute immobility. (c) *Bony ankylosis* or synostosis is an osseous union between articulating surfaces (Figs. 264 and 265). It may follow upon fibrous or cartilaginous ankylosis, or may result from the fusion of two articular surfaces which have lost their cartilage and become covered with granulations. In the majority of cases it is to be regarded as a reparative process, presenting analogies with the union of a fracture.

Other forms of osseous ankylosis occur, the etiology and pathology of which are as yet unknown. The name *arthritis ossificans* has been applied by Joseph Griffiths to one group of these. The alleged occurrence of ankylosis from disuse of a joint has not been corroborated.

The occurrence of ankylosis in a joint before the skeleton

has attained maturity does not appear to impair the growth in length of the bones affected. When there is arrest of growth, it depends on changes in the ossifying junctions caused by the original disease.

To differentiate between museular fixation and ankylosis, it may be necessary to anæsthetise the patient. The nature and extent of ankylosis may be learned by manipulating the limb or by skiagraphy. In fibrous as contrasted with osseous ankylosis mobility may be elicited, although only to a limited extent; while in osseous ankylosis the joint is rigidly fixed, and attempts to move it are painless.

The *treatment* is influenced by the nature of the original lesion, the variety of the ankylosis, and the attitude of the joint. When there is restriction of movement due to fibrous adhesions, these may be elongated or ruptured. Elongation of the adhesions may be effected by manipulations, exercises, and the use of special forms of apparatus—such as extension, or the application of weights to the limb. Massage and douching are also useful. A course of injections of fibrolysin may soften fibrous adhesions and admit of their being stretched. It may be necessary to administer an anæsthetic before rupturing strong fibrous adhesions, and this procedure must be carried out with caution, in view of such risks

as fracture of the bone—which is often rarefied—or separation of an epiphysis. There is also the risk of fat embolism, and of re-starting the original disease. The giving way of adhesions may be attended with an audible crack; and the procedure is often followed by considerable pain and effusion into the joint, which necessitate rest for some days before exercises and manipulations are resumed. The adhesions that result from injury of a joint are more amenable to treatment than those following disease.

Operative treatment may be called for in cases in which the bones are closely bound to one another by fibrous or by osseous tissue.



FIG. 264.—Osseous Ankylosis of Femur and Tibia in position of flexion.

Arthrolysis, which consists in opening the joint and dividing the fibrous adhesions, is almost inevitably followed by their reunion.

Arthroplasty.—Murphy of Chicago devised this operation for restoring movement to an ankylosed joint. It consists in transplanting between the bones a flap of fat-bearing tissue, whereby a bursal cavity is formed lined with endothelium and containing a fluid rich in mucin.

In operating for fibrous ankylosis, such as may result, for example, from gonorrhœal synovitis, the contracted and adherent capsule and other ligaments are removed by dissection as freely as possible, and the fibrous adhesions between the bones divided until the movements of the joint are easy and flail-like. A flap of fat-bearing fascia is then dissected up, interposed between the bones, and secured in position by sutures; when the wound has healed, massage and movement are commenced.



FIG. 265.—Osseous Ankylosis of Knee in the flexed position following upon Tuberculous Arthritis.

(Anatomical Museum, University of Edinburgh.)

In operating for osseous ankylosis, before interposing the flap, the bones are separated along the line of union and the ends trimmed off sufficiently to give perfectly free movements, and any bony prominences which might interfere with movement are also removed. In the elbow, the flap is taken from the posterior surface of the triceps, and

should contain both fat and a layer of muscle; in the hip and knee, the flap is taken from the fascia lata.

When arthroplasty is impracticable, a simpler operation may be performed. If the ankylosis is osseous and a movable joint is desired—for example, at the elbow—a considerable amount of bone, and it may be also of periosteum and capsular ligament, are resected to allow of the formation of a false joint.

When bony ankylosis has occurred with the joint in an undesirable attitude—for example, flexion at the hip or knee, it can be remedied by osteotomy or by a wedge-shaped resection

of the bone, with or without such additional division of the contracted soft parts as will permit of the limb being placed in the attitude desired.

Bony ankylosis of the joints of a finger, whether the result of injury or disease, is difficult to remedy by any operative procedure, for while it is quite possible to restore mobility, the new joint is apt to be flail-like and useless.

Errors of Development.—These include congenital dislocations and other deformities of intra-uterine origin, such as abnormal laxity of joints, absence, displacement, or defective growth of one or other of the essential constituents of a joint.

The more important of these are described along with Deformities of the Extremities.

DISEASES OF JOINTS

Bacterial Diseases.—In the great majority of bacterial diseases the organisms are carried to the joint in the blood-stream. They may lodge either in the synovial membrane or in one of the bones, whence the disease subsequently spreads to the other structures of the joint. Organisms may also be introduced into joints through accidental or operation wounds, such as the removal of a loose cartilage or the suture of a fractured patella. It has been shown experimentally that joints are among the most susceptible parts of the body to infection, and this would appear to be due to the viscid character of the synovial fluid, which protects micro-organisms from the bactericidal agents in the tissues and fluids of the body (Noetzel).

PYOGENIC DISEASES

The commoner pyogenic diseases are the result of infection of one or other of the joint structures with *staphylococci* or *streptococci*, which may be demonstrated in the exudation into the joint and in the substance of the synovial membrane. The mode of infection is the same as in the pyogenic diseases of bone. The localisation of the infection in a particular joint is determined by injury, exposure to cold, antecedent disease of the joint, or other factors whose nature is not always apparent. The effects on the joint vary widely in severity. There is always engorgement and infiltration of the synovial membrane, and an effusion into the cavity of the joint, which in the

milder forms is serous—*serous synovitis*; flakes of fibrin are suspended in the fluid and deposited on the surface of the membrane. In severe infections the exudate is purulent—*purulent* or *suppurative synovitis*—and consists of pus mixed with fibrin, and, it may be, red blood corpuscles; the synovial membrane and the ligaments which it invests are converted into granulation tissue, and the surface of the membrane presents granulations resembling those on the surface of an ulcer; foci of suppuration may develop in the peri-articular cellular tissue and result in abscesses. In *acute arthritis*, all the structures of the joint are involved in the infection. The articular cartilage is encroached upon and invaded by the granulation tissue derived from the synovial membrane, and from the marrow of the subjacent bone. It presents a worm-eaten or ulcerated appearance, or it may undergo necrosis and separate. The removal of the cartilage and exposure of the subjacent bone allows of the eruption of granulation tissue from the marrow and the disintegration of the osseous trabeculæ, the latter condition being described as *caries*. With the destruction of the ligaments, the stability of the joint is lost, and it is said to be “disorganised.” When the infection has originated in the marrow of an adjacent bone, as is the case in the acute arthritis of infants, the sequence of events differs slightly from the above description, but the changes are essentially the same.

The *clinical features* vary with the gravity and extent of the infection. When this is confined to the synovial and peri-synovial tissues—*acute serous* and *purulent synovitis*—there is the usual general reaction, associated with a feeling of illness and attended with pyrexia, and there is great pain in the joint. On examination, the part is found to be hot and swollen, the swelling assumes the shape of the distended synovial sac, fluctuation can usually be elicited, and the joint is held in the flexed position.

If the infection involves all the joint structures—*acute arthritis*—the general and local phenomena are intensified, the temperature rises quickly, often with a rigor, and remains high; the patient looks ill, and is either unable to sleep or the sleep is disturbed by starting pains. The joint is held rigid in the flexed position by involuntary contraction of the muscles, and the least attempt at movement causes severe pain; the slightest jar—even the shaking of the bed—may cause agony. The joint is hot, tensely distended, the skin over it may be flushed, and there may be œdema of the peri-articular

tissues or of the limb as a whole. If the pus perforates the joint capsule, there are signs of abscess or of diffuse suppuration in the cellular tissue. The final disorganisation of the joint is indicated by abnormal mobility and grating of the articular surfaces, or by spontaneous displacement of the bones, and this may amount to complete dislocation. In the acute arthritis of infants, the epiphysis concerned may be separated and displaced.

In certain cases of pyogenic infection the disease remains latent for a time, and the clinical manifestations are so slight that they may escape notice until some striking development, such as dislocation, draws attention to them. This latency is observed chiefly in the hip, when the joint has become infected in the course of some acute illness, such as scarlet or typhoid fever, or pyæmia.

In the course of *pyæmia*, joints may become distended with pus without any pronounced changes in the joint structures, without local signs except those indicating the presence of fluid, and without much complaint on the part of the patient.

When the *joint is infected through an external wound*, the anatomical and clinical features are similar to those observed when the infection has reached the joint by the blood-stream, but the destructive changes tend to be more severe and are more likely to result in disorganisation.

The *terminations* vary with the gravity of the infection and with the stage at which treatment is instituted. In the milder forms recovery is the rule, with more or less complete restoration of function. In the more severe forms, and especially when several joints are involved, death may result from septic poisoning. If the patient recovers, the joint or the entire limb may be permanently damaged. There may be fibrous or bony ankylosis, or there may be deformity from displacement or dislocation. From changes in the peri-articular structures there may be contracture in an undesirable position, and in young subjects there may be interference with the growth of the limb. The persistence of sinuses is usually due to disease in one or other of the adjacent bones.

The *treatment* is carried out on the same principles as in other pyogenic infections. Any infective lesion elsewhere in the body from which the joint may have become infected should be dealt with. The limb is immobilised in such an attitude that should stiffness occur there will be the least interference with function. Extension by weight and pulley is a valuable means of relieving symptoms and counteracting the tendency to flexion.

The induction of hyperæmia is sometimes remarkably efficacious in relieving pain, and in arresting the progress of the infection. If the fluid in the joint is in sufficient quantity to cause tension, if it persists, or if there is reason to suspect that it is purulent, it should be withdrawn without delay; an exploring syringe will suffice in the serous variety, the suppurative forms demand incision and drainage. A vaccine may be prepared from the fluid thus obtained and injected into the patient. It is a common experience that many forms of acute suppuration in joints—for example, the acute arthritis of infants, and the suppurations in pyæmia—yield at once to incision and drainage if carried out sufficiently early and before any destructive changes have taken place.

In other cases simple drainage may not prove satisfactory, and indications of progressive mischief call for further interference. Continuous irrigation with salt solution or peroxide of hydrogen may be tried, or the joint may be laid freely open so that every pocket and recess is exposed. In certain joints this is only attainable by the resection of a portion of one or other of the bones.

Suppuration in the peri-articular soft parts or in one of the adjacent bones must be looked for and promptly dealt with.

Amputation is only to be had recourse to if life is threatened by general infection.

When convalescence is established, attention is directed to the restoration of the functions of the limb, and to the prevention of stiffness and deformity by movements and massage, and the use of hot-air and other baths.

At a later stage, and especially in neglected cases, operative and other measures may be required for deformity or stiffness.

Other Forms of Pyogenic Infection.—In typhoid fever, joint lesions may result from infection with the typhoid bacillus or with ordinary pyogenic organisms, and run their course with or without suppuration. The destructive process may take place in the joint without symptoms, and attention only be called to the condition by the occurrence of dislocation on slight movement, or on lifting the patient.

Joint lesions are comparatively common in scarlet fever, and were formerly described as scarlatinal rheumatism. The most frequent clinical type is that of a serous synovitis, occurring within a week or ten days from the onset of the fever. It is most common in females over fifteen years, and its favourite

seat is in the hand and wrist, the sheaths of the extensor tendons as well as the synovial membrane of the joints being involved. It does not tend to migrate to other joints, and rarely lasts longer than a few days. It is probably due to the specific virus of scarlet fever.

At a later stage, especially in children and in cases in which the throat lesion is severe, an arthritis is sometimes observed which may be acute and suppurative, may affect several joints and exhibit a septicæmic or pyæmic character.

There is also described a "true rheumatic arthritis" occurring when convalescence from scarlet fever is well advanced; this form is sometimes complicated with endocarditis and with chorea, and is favourably influenced by anti-rheumatic remedies.

Pneumococcal affections of joints, the result of infection with the pneumococcus of Fraenkel, are being met with in increasing numbers. The local lesion varies from a *synovitis* with infiltration of the synovial membrane and effusion of serum or pus, to an *acute arthritis* with erosion of the cartilage, caries of the articular surfaces, and disorganisation of the joint. Of all the articulations the knee is that most frequently affected, but several joints may suffer at the same time. In most of the recorded cases the joint affection makes its appearance a few days after the commencement of a pneumonia, but in a number of instances, especially among children, the lung is not specially involved, and the condition is an indication of a generalised pneumococcal infection, which may manifest itself by endocarditis, empyema, meningitis or peritonitis, and it frequently has a fatal termination. The differential diagnosis from other forms of pyogenic infection is established by aspirating the fluid in the joint and submitting it to bacteriological examination. The treatment is carried out on the same lines as in ordinary pyogenic infections, and, it may be, also by the administration of vaccines.

In **measles, diphtheria, smallpox, influenza, and dysentery**, joint lesions may occur, but they are less frequent than in typhoid and scarlet fever.

The joint lesions which accompany **acute rheumatism** or rheumatic fever are believed to be due to a diplococcus. In the course of a general illness in which there is moderate pyrexia and profuse sweating, some of the larger joints, and not infrequently the smaller ones as well, become swollen and extremely tender, so that the sufferer lies in bed quite helpless, dreading the slightest movement. From day to day fresh

joints are attacked, while those first affected begin to subside, often with great rapidity. Affections of the heart-valves and of the pericardium are commonly present. On recovery from the acute illness, it may be found that the joints have entirely recovered, but in a small proportion of cases certain of them remain stiff and pass into the crippled condition described under chronic rheumatism. For the treatment of acute rheumatism the reader is referred to works on Medicine, but it may here be said with regard to the joints that there is no call for operative interference.

Gonorrhœal Affections of Joints.—These include all forms of joint lesion associated with gonorrhœal urethritis, vulvovaginitis, and gonorrhœal ophthalmia. They may develop at any stage of a urethritis, and are most frequently met with when the infection has reached the posterior urethra; they have been observed, however, after the discharge has ceased. There is no connection between the severity of the gonorrhœa and the incidence of joint disease. In women, a gonorrhœal discharge must be differentiated from other forms by bacteriological examination.

As a complication of ophthalmia, the joint lesions are chiefly met with in infants, and occur more commonly towards the end of the second or during the third week.

The gonococcus is carried to the joint in the blood-stream and is first deposited in the synovial membrane, in the tissues of which it can usually be found; it may be impossible to find it in the exudate within the joint. The joint lesions may be the only evidence of metastasis, or they may be part of a general infection involving the endocardium, pleura, and tendon sheaths.

The joints most frequently affected are the knee, elbow, ankle, wrist, and fingers.

Several clinical types may be differentiated. (1) There is a *dry polyarthritis* met with in the joints and tendon sheaths of the wrist and hand, formerly described as gonorrhœal rheumatism, which in some cases is trifling and evanescent, and in others is persistent and progressive, and results in stiffness of the affected joints and permanent crippling of the hand and fingers.

(2) The commonest type is a *chronic synovitis* or *hydrops*, in which the joint—very often the knee—becomes filled with a serous or sero-fibrinous exudate. There is no thickening of the capsule and there are no reactive changes in the cellular tissue or skin, nor is there any fever or disturbance of health.

The movements are free except in so far as they are restricted by the amount of fluid in the joint. It usually subsides in two or three weeks under rest, but may relapse. When recovery takes place, it is usually complete.

(3) An *acute synovitis* with peri-articular phlegmon is most often met with in the elbow, but it occurs also in the knee and ankle. There is a sudden onset of severe pain and swelling in and around the joint, with considerable fever and disturbance of health. The slightest movement causes pain, and the part is very sensitive to touch. The skin is hot and tense, and in the case of the elbow may be red and fiery as in erysipelas.

The deposit of fibrin on the synovial membrane and on the articular surfaces may lead to the formation of adhesions, sometimes in the form of isolated bands, sometimes in the form of a close fibrous union between the bones.

(4) A *suppurative arthritis*, like that caused by ordinary pus microbes, may be the result of gonococcal infection alone or of a mixed infection. Only one joint is usually infected, but the condition may be multiple. The articular cartilages are destroyed, the ends of the bones are covered with granulations, extra-articular abscesses form, and complete osseous ankylosis usually results.

The *diagnosis* of gonorrhœal affections of joints is often missed, because the possibility of gonorrhœa is not suspected by the practitioner. The denial of the disease by the patient is not always to be relied upon, especially in the case of women, who may be ignorant of its presence. The chief points in the differential diagnosis from acute articular rheumatism are, that the gonorrhœal affection is more often non-articular, has little tendency to wander from joint to joint, and its progress is not appreciably influenced by salicylates, although these drugs may relieve the pain. The conclusive point is the recognition of a gonorrhœal discharge or of pus threads in the urine.

The disease may prove persistent or may relapse, and the patient may be laid up for weeks or months, and may finally be crippled in one or in several joints.

The *treatment*—besides that of the urethral disease or of the ophthalmia—consists in rest until all pain and sensitiveness have disappeared. The pain may be relieved by salicylates, but most benefit follows on the induction of hyperæmia by the rubber bandage and hot-air baths, and by the administration of vaccines; the best results are obtained by injecting the vaccine into the joint, at intervals of seven to ten days, until there is no tendency to relapse.

König recommends the use of tincture of iodine to the extent of blistering. In the persistent dry form, hot-air baths are helpful. In hydrops, when the fluid persists, the joint should be tapped, the fluid withdrawn, and about one ounce of a 1 per-cent. solution of protargol injected; the patient should be warned of the marked reaction which follows. The purulent form is treated by incision and drainage.

After all symptoms have settled down, but not till then, for fear of exciting relapse or metastasis, the joint may be massaged and exercised. Stiffness from adhesions is most intractable, and may, in spite of every attention, terminate in ankylosis. Forceful breaking down of adhesions under anæsthesia is not recommended.

TUBERCULOUS DISEASES

Tuberculous diseases of joints result from bacillary infection of the synovial membrane or of the marrow of one of the adjacent bones, under conditions similar to those which have been described as occurring in tuberculous disease of bone.

From the anatomical point of view, they may be divided into those in which the disease originates in the synovial membrane, and those in which it originates in one of the adjacent bones. The relative frequency of these two types varies with the age of the patient and with the joint affected. In children, the number of cases beginning in the bones is approximately three times as great as those beginning in the synovial membrane, while in adults the disease most frequently originates in the synovial membrane. As regards the joint affected, the maximum frequency of osseous lesions is found in the hip—in the proportion of five osseous to one synovial; in the knee and in the other large joints, the proportion is about equal (König). The predominance of bone lesions in childhood and youth is to be ascribed to the active changes taking place at the ends of the long bones.

Morbid Anatomy.—When there is tuberculous disease in the articular end of a long bone, it may give rise to *reactive changes* in the adjacent joint, characterised by effusion and by the extension of the synovial membrane over the articular surfaces. This may result in the formation of adhesions which obliterate the cavity of the joint or divide it into compartments. These lesions are comparatively common, and are often erroneously regarded as resulting from tuberculous infection of the joint.

The *actual infection of the joint* by tubercle originating in the adjacent bone may take place at the periphery, the osseous focus reaching the surface of the bone at the site of the reflection of the synovial membrane, and the infection which begins at this point then spreads to the rest of the membrane. Or it may take place in the central area, by tuberculous pus escaping into the joint through a hole in the articular cartilage, or by the projection of tuberculous granulation tissue into the joint following upon gradual erosion of the cartilage (Fig. 266).

Changes in the Synovial Membrane.—In the majority of cases there is found a *diffuse thickening of the synovial membrane*, due to the formation of granulation tissue, or of young connective tissue, in its substance. This new tissue may be described as being arranged in two layers—the outer layer composed of fully formed connective or fibrous tissue, while the inner consists of embryonic tissue, usually permeated with miliary tubercles. On opening the joint, these tubercles may be seen on the free surface of the synovial membrane, or the surface may be covered with a layer of fibrinous or caseous tissue. Where there is greater resistance on the part of the tissues, there is active formation of young connective tissue which circumscribes or encapsulates the tubercles, so that they remain embedded in the substance of the membrane, and are only seen on cutting into it.

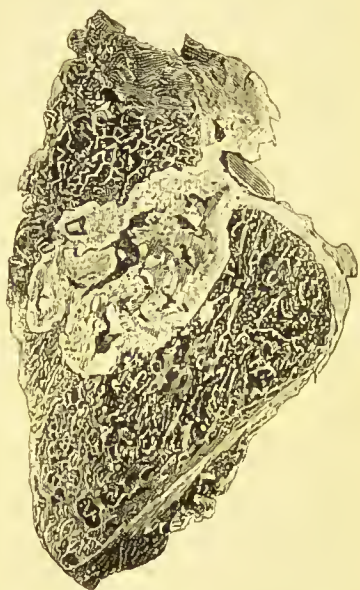


FIG. 266.—Section of Upper End of Fibula, showing caseating focus in marrow, erupting on articular surface and infecting joint.

The diseased synovial membrane tends to be projected into the cavity of the joint, filling up its pouches and recesses, and spreading over the surface of the articular cartilage like ivy growing on a wall (Fig. 293). Wherever the synovial tissue covers the cartilage it becomes adherent to and fused with it, as covered cartilage always undergoes a retrograde metaplasia into ordinary connective tissue. The morbid process may be arrested at this stage, and may cure with fibrous adhesions between the opposing articular surfaces, or it may progress, in

which case further changes occur, resulting in destruction of the articular cartilages and exposure of the subjacent bone.

In rare instances the synovial membrane presents nodular masses or lumps, resembling the tuberculous tumours met with in the brain. They project into the cavity of the joint, are often pedunculated, and may give rise to the symptoms of a loose body. The fringes of synovial membrane may also undergo a remarkable development, like that observed in arthritis deformans. Both these types are most frequently met with in the knee.

The Contents of Tuberculous Joints.—In a large proportion of cases of synovial tuberculosis the joint is entirely filled up by the diffuse thickening of the synovial membrane. In a small number there is an abundant serous exudate, and the condition is known clinically as *tuberculous hydrops*. There may be a considerable formation of fibrin, covering the free surface of the membrane and floating in the fluid as shapeless flakes or masses. Under the influence of joint movements this fibrin may assume the shape of melon-seed bodies. More rarely the joint contains pus, and the surface of the synovial membrane resembles the wall of a cold abscess.

Ulceration of Cartilage.—When the synovial tissue covering the cartilage acquires the characters of a tuberculous infiltration, it causes pitting and perforation of the cartilage, makes its way through it, and often spreads widely between it and the subjacent bone, so as to separate the cartilage, sometimes in portions of considerable size. The cartilage may be similarly ulcerated or detached as a result of disease in the bone. These are the changes commonly spoken of as ulceration and necrosis of cartilage.

Caries of Articular Surfaces.—Changes in the bone consisting in tuberculous infiltration of the marrow in the surface cancelli, and breaking up of the spongy framework of the bone into minute irregular fragments, may precede or follow upon destruction of the articular cartilage. The disintegration of the bone is known as caries.

When the destructive changes in the articular surfaces are very pronounced, and when at the same time there is an absence of caseation and suppuration, the condition is called *caries sicca*.

The pressure of articular surfaces against one another favours the progress of ulceration of cartilage and of articular caries. These processes are usually more advanced in the areas most exposed to pressure—for example, in the case of the hip-joint,

on the superior aspect of the head of the femur and on the posterior and upper segment of the acetabulum.

The occurrence of *pathological dislocation* is due to softening and stretching of the ligaments which normally retain the bones in position, and to some factor causing displacement, which may be the accumulation of fluid or of granulations in the joint, the involuntary contraction of muscles, or some movement or twist of the limb. The occurrence of dislocation is also favoured by destructive changes in the bones.

Peri-articular tubercle and abscess may result from the spread of disease from the bone or joint into the surrounding tissues, either directly or by way of the lymphatics. A peri-articular abscess may spread in several directions, sometimes invading tendon sheaths or bursæ, and finally reaching the skin surface by tortuous sinuses.

Reactive changes in the vicinity of tuberculous joints are of common occurrence, and play a considerable part in the production of what is clinically known as *white swelling*. New connective tissue forms in the peri-articular fat and between muscles and tendons. It may be tough and fibrous, or soft, vascular, and cedematous, and the peri-articular fat becomes swollen and gelatinous, constituting a layer of considerable thickness. The fat disappears and is replaced by a mucoid effusion between the fibrous bundles of connective tissue. This is what was formerly known as *gelatinous degeneration* of the synovial membrane. In the case of the wrist the newly formed connective tissue may fix the tendons in their sheaths, seriously interfering with the movements of the fingers. In relation to the bones there may also be reactive changes, resulting in the formation of spicules of new bone on the periosteal surfaces and at the attachment of the capsular and other ligaments.

Terminations and Sequelæ.—A natural process of cure may occur at any stage of the disease, the tuberculous tissue being replaced by healthy connective and scar tissue. Recovery is apt to be attended with impairment of movement due to the occurrence of adhesions, ankylosis, or contraction of the peri-articular structures. Caseous foci in the interior of the bones may become encapsulated, and a cure thus be effected, or they may be the cause of a relapse of the disease at a later date. Interference with growth is comparatively common, and may involve only the epiphysial junctions in the immediate vicinity of the joint affected, or those of all the bones of the limb. This is well seen in adults who have suffered from severe disease of the hip in childhood—the entire limb, including the

foot, being shorter and smaller than the corresponding parts of the opposite side.

Atrophic conditions are also met with, the bones undergoing fatty atrophy, so that in extreme cases they may be cut with a knife or be easily fractured. This is to be borne in mind in forcibly manipulating stiff joints. These atrophic conditions are largely due to disuse of the limb affected, and are recovered from if it is able to resume its functions.

Clinical Features.—These vary with the different anatomical forms of the disease, and with the joint affected. The symptoms do not always correspond with the nature and severity of the local lesions, and it is not uncommon to find, when the joint is exposed by operation, that the disease is much more extensive than might have been inferred from the clinical features.

Sometimes the disease is ushered in by a febrile attack attended with pains in several joints—described by John Duncan as *tuberculous arthritic fever*. This is liable to be mistaken for rheumatic fever, from which, however, it differs in that there is no real migration from joint to joint; there is an absence of sweating and of cardiac complications; and no benefit follows the administration of salicylates.

In exceptional cases, tuberculous joint disease follows an acute course resembling that of the pyogenic arthritis of infants. This has been observed in young children, especially in the knee, the lesion being in the synovial membrane, and attended by an accumulation of pus in the joint. If promptly treated by incision and drainage, recovery is rapid, and free movement of the joint may be preserved.

The onset and early stages of tuberculous disease, however, are more often insidious, and are attended with so few symptoms that the disease may have obtained a considerable hold before it attracts notice. It is not uncommon for patients or their friends to attribute the disease to injury, as it often first attracts attention after some slight trauma or excessive use of the limb. The symptoms usually subside under rest, only to relapse again with use of the limb.

The initial local symptoms may be those associated with the presence of a focus in the neighbouring bone, perhaps causing neuralgic pains in the joint, or weakness, tiredness, stiffness, and inability to use the limb, these symptoms improving with rest and being aggravated by exertion.

It is rarely possible by external examination to recognise deep-seated osseous foci in the vicinity of joints; but if they are near the surface in a superficial bone—such as the head of

the tibia—there may be local thickening of the periosteum, œdema, pain, and tenderness on pressure and on percussion. Large foci may be revealed by the X-rays; a mass of cheesy tubercle shows as a clear area with an ill-defined margin, a sclerosed focus gives a much denser shadow than the surrounding bone, and a sequestrum presents a dark shadow of irregular contour, and a clear zone between it and the adjacent bone.

In the examination of the patient, attention must be specially directed to the wasting of muscles, the impairment or loss of the normal movements of the joint, and the presence of abnormal attitudes of the limb.

Wasting of muscles is a constant accompaniment of tuberculous joint disease. It is to be attributed partly to want of use, but chiefly to reflex interference with the trophic innervation of the muscles. It is specially well seen in the extensor and adductor muscles of the thigh in disease of the knee, and in the deltoid in disease of the shoulder. The muscles become soft and flaccid, they exhibit tremors on attempted movement, and their excitability to the faradic current is diminished. The muscular tissue may be largely replaced by fat.

Impairment or loss of the normal movements varies in degree according to the nature and seat of the disease. In the early stages of synovial tuberculosis the movements may be merely restricted in range. When any joint of the lower extremity is affected, there is usually a limp in walking. When the articular surfaces are involved, all movements, whether active or passive, are usually abolished, and the condition presented is one of fixation or *rigidity*. This results from involuntary contraction of the muscles; it disappears under an anæsthetic, but returns on waking. The recognition of rigidity is of great diagnostic value, especially in deeply seated joints such as the shoulder and hip, and in the spine.

Abnormal attitudes of the limb may precede other symptoms of joint disease, but are more frequently of later development. In mild cases they may be absent altogether. They occur earlier, and are more pronounced in cases in which pain and other irritative symptoms of articular disease are well marked, and are best illustrated by the attitudes assumed in disease of the hip. They are due to reflex or involuntary contraction of the muscles acting on the joint, with the object of placing it in the attitude of greatest ease, and they disappear under anæsthesia. With the lapse of time they not only become exaggerated, but may become permanent from ankylosis, or from contracture of the soft parts round the joint.

Startings at night, which are frequently met with in the stage of muscular fixation, are to be regarded as indications that the disease of the articular surfaces is progressive.

The formation of extra-articular abscess is a common accompaniment of tuberculous joint disease. The abscess may appear early and form a prominent feature in the clinical picture, or it may not develop till long after the original disease has subsided. It may develop so insidiously that it does not attract attention until it has attained considerable size, especially when associated with disease of the spine, pelvis, or hip. The abscess presents itself at a definite situation in relation to the different joints, determined by the anatomical relationships of the capsule and synovial membrane to the surrounding tissues. The bursæ and tendon sheaths in the vicinity may influence the direction of spread of the abscess and the situation of resulting sinuses. When left to burst of itself, or when opened and allowed to become infected with pyogenic bacteria, there is not only the risk of aggravation of the disease and persistent suppuration, but there is a greater liability to general tuberculosis.

When sinuses form, they are often so tortuous that it is difficult to pass a probe down to the focus from which the abscess took its origin; if injected with an emulsion of bismuth, their course can be traced with the X-rays.

Tuberculous infection of the lymphatic glands of the limb is exceptional, but may follow upon infection of the skin around the orifice of a sinus.

The occurrence of *pyrexia* usually indicates suppuration, or the dissemination of the tubercle—for example, to the lungs or membranes of the brain. A slight rise of temperature in the evening may be induced in quiescent joint lesions by injury or by movement of the joint under anaesthesia, or by the fatigue of a railway journey. The development and spread of an abscess may also be attended with an evening rise of temperature; but when the abscess is quiescent the temperature usually remains normal. A temperature chart, therefore, may afford useful information. When sinuses have formed and become septic, there may be a diurnal variation in the temperature of the type known as hectic fever (Fig. 6).

Relative Frequency of Tuberculous Disease in different Joints.
—Hospital statistics show that joints are affected in the following order of frequency: Spine, knee, hip, ankle and tarsus, elbow, wrist, shoulder. The hip and spine are most often affected in childhood and youth, the shoulder and

wrist in adults; the knee, ankle, and elbow show little age preference.

CLINICAL TYPES OF TUBERCULOUS JOINT DISEASE

Tuberculous hydrops is the result of a purely synovial lesion, and its outstanding feature is the accumulation of fluid within the joint. It is analogous to the ascitic form of peritoneal tuberculosis and to the serous effusion in tuberculous disease of the pleura. It is the chief representative of the "chronic simple synovitis" of the older authors. As it frequently terminates in recovery with a useful joint, it may be regarded as the least serious form of tuberculous joint disease. It is most often met with in the knee, and will be described with the affections of that joint.

Cold Abscess or Empyema of Joints.—The special feature of this type consists in the accumulation of tuberculous pus within the joint. It is analogous to the purulent type of peritoneal tuberculosis and tuberculous empyema. It is most often met with in the knee, and is usually the result of tuberculosis of the synovial membrane. It occurs in those who are reduced in health, and are the subjects of tuberculous lesions elsewhere. Its clinical features resemble those of hydrops so closely that the differential diagnosis is rarely made until the fluid is withdrawn by means of an exploring syringe. The prognosis is less favourable than in hydrops.

Diffuse Thickening of the Synovial Membrane.—**White Swelling of Joints.**—*Tumor albus* was the name originally applied by Wiseman in 1676 to that form of tuberculous disease which is characterised by the gradual development of an elastic swelling in the region of a joint. It has already been pointed out that this swelling is to a considerable extent the result of inflammatory and mucoid changes in the fat and connective tissue surrounding the capsule of the joint, as well as of tuberculous thickening of the synovial membrane. It may originate from tuberculosis starting in the synovial membrane as well as from disease in the bone. The changes within the joint and the course of the disease vary within wide limits. The appearances of white swelling bulk so largely in the clinical features of tuberculous joint disease that it is probably the best known clinical type. It is well seen in joints which are superficial—such as the knee, ankle, elbow, and wrist. The swelling, which is the first and most prominent clinical feature, develops gradually and painlessly, obliterating

the bony prominences by filling up the natural hollows (Fig. 280). It appears greater to the eye than is borne out by measurement, being thrown into relief by the wasting of the muscles above and below the joint. In the early stage the swelling is elastic, doughy, and non-sensitive, and corresponds very accurately to the superficial area of the synovial membrane involved. At this stage there is comparatively little complaint on the part of the patient, for the articular surfaces and ligaments are still intact. There may be a feeling of weight in the limb, and in the case of the knee and ankle the patient may tire on walking and drag the leg with more or less of a limp. The movements of the joint are painless, although usually somewhat limited in range. The disability is increased by use and exertion, but, for a time at least, it improves under rest.

If the disease is not checked, the signs and symptoms become more marked. The skin over the joint becomes tense and hot, the swelling, which was at first firm and elastic, may show areas of softening, and later of fluctuation; and a cold abscess may form and produce one or more sinuses by bursting through the skin. The wasting of muscles increases, the joint becomes rigid as the articular cartilages become affected, and the attitude of flexion is very commonly assumed, more especially in the case of the knee. Starting pains at night indicate destructive changes in the articular surfaces. The final condition is one of disorganisation of the joint, with deformity and multiple sinuses.

Tuberculous Arthritis.—It is convenient to group under this heading those cases in which the early and outstanding clinical features are the result of implication of the articular surfaces. Although, as already indicated, these symptoms commonly develop in the later stages of white swelling, it is a matter of everyday experience that symptoms of implication of the articular surfaces may be the first evidence of tuberculous joint infection, and may exist without white swelling or any other clinical sign of disease in the synovial membrane. These remarks apply specially to such deeply seated joints as the hip, shoulder, and spine. The recognition of this form of tuberculous joint disease depends rather upon inferences founded upon certain symptoms and signs than upon examination of the joint itself. The patient complains of pain in the joint, or refers it to some other part which shares the same nerve supply; for example, in hip disease the pain is often referred to the knee through the obturator nerve. The pain

is aggravated by attempts at movement, and in the case of the joints of the lower extremity the patient limps in walking. The movements of the joint are restricted or abolished, and wasting of muscles is more marked than in the early stage of white swelling. Very commonly the limb assumes an abnormal attitude as a result of the contraction of particular groups of muscles.

In the more advanced stages other signs make their appearance, such as starting pains, the formation of abscess and of sinuses, displacement or even dislocation of the bones. Under an anæsthetic the joint may be found to be completely disorganised, with destruction of ligaments, abnormal mobility, and grating of the articular surfaces.

Caries sicca is the name given by Volkmann to a very chronic form of tuberculous arthritis, which is met with chiefly in the shoulder and hip, between the ages of fifteen and thirty-five. There is an entire absence of swelling, a characteristic wasting of all the structures in the vicinity of the joint, and the bony prominences—such as the acromion and coracoid in the case of the shoulder, and the trochanter at the hip—stand out prominently. Passive movements are restricted, and are attended with severe pain. The general health usually remains unimpaired, although the disease may be of long standing. Suppuration is exceptional, and when it occurs is usually associated with the presence of a sequestrum.

Influence of Tuberculous Joint Disease on the General Health.—Experience shows that the early stages of tuberculous joint disease may be compatible with the appearance of good health. As a rule, however, and especially if there is mixed infection, the health suffers, the appetite is impaired, the patient is easily tired and complains of failure of strength, and there may be some loss of weight and evening pyrexia.

Tuberculous disease of the lung is a frequent concomitant in adults, and may precede the joint disease, or may appear later. In children, acute miliary tuberculosis may occur, and the clinical features are frequently those of tuberculous meningitis; it sometimes follows on comparatively trivial operations, and is usually rapidly fatal.

Diagnosis.—In typical cases the diagnosis is usually easy. A history of tuberculosis in the family, or of other tuberculous lesions in the patient, an insidious onset, and the fact that there is a considerable interval between the receipt of an alleged injury and the appearance of symptoms, all suggest the

tuberculous origin of a given case of joint disease. The X-rays are of value chiefly in the recognition of osseous lesions. The use of tuberculin tests is to be recommended in obscure cases.

The **prognosis** depends upon so many factors that it is impossible to make any general statement regarding it. Recovery is seldom impossible, but the existence of tuberculous lesions elsewhere or of septic sinuses are unfavourable factors. While tuberculous lesions in children tend to become circumscribed, the tendency in adults is in the opposite direction. The milder forms of synovial tuberculosis may be entirely recovered from, but severe bone lesions tend to cause serious forms of joint disease which have little tendency to natural cure. The locality of the disease is an important factor, the prognosis being much more unfavourable in the hip and spine than in other joints.

The length of time required for complete recovery necessarily varies, but may be stated generally as being from one to three years. The patient or his friends should be informed of this, and of the risk of relapse.

Treatment.—In addition to the general treatment of tuberculosis, which must always be enforced, local measures are to be employed. These may be described under two heads—the conservative and the operative.

Conservative treatment is almost always to be employed in the first instance, as by it a larger proportion of cures is obtained with a smaller mortality and with better functional results than by operation.

Treatment by rest implies the immobilisation of the diseased limb until pain and tenderness have disappeared. The attitude in which the limb is immobilised should be that in which, in the event of subsequent stiffness, it will be most serviceable to the patient. Immobilisation may be secured by bandages, splints, extension, or other apparatus. *Extension* with weight and pulley is of great value in securing rest, especially in disease of the hip or knee; it eliminates muscular spasm, relieves pain and startings at night, and prevents abnormal attitudes of the limb. If, when the patient first comes under observation, the limb is in a deformed attitude which does not readily yield to extension, this should be corrected under an anæsthetic. The permanently deformed attitudes due to contraction of the soft parts or to ankylosis will be considered later.

The induction of hyperæmia is helpful in some cases, the

rubber bandage being applied for an hour or so morning and evening.

Injection of Iodoform.—In hydrops and empyema of joints this is carried out on the same lines as have been described for tuberculous abscess. After the fluid contents of the joint are withdrawn, the iodoform is injected; and this may require to be repeated in a month or six weeks.

After the injection of iodoform there is usually considerable reaction, attended with fever (101° F.), headache, and malaise, and considerable pain and swelling of the joint. In some cases there is sickness, and there may be blood pigment in the urine. The severity of these phenomena diminishes with each subsequent injection.

The use of blisters and of the actual cautery has largely gone out of fashion, but these measures may be employed with benefit for the relief of pain when this is a prominent feature.

The application of the X-rays has proved beneficial in synovial lesions in superficial joints such as the wrist or elbow; prolonged exposures are made at fortnightly intervals, and on account of the cicatricial contraction which attends upon recovery, the joint must be kept in good position.

Conservative treatment is only abandoned if improvement does not show itself after a thorough trial, or if the disease relapses after apparent cure.

Operative Treatment.—Other things being equal, operation is more often indicated in adults than in children, because after the age of twenty there is less prospect of spontaneous recovery, there is more tendency for the disease to relapse and to invade the internal organs, and there is no fear of interfering with the growth of the bones. The state of the general health may necessitate operation as the most rapid method of removing the disease. The social status of the patient must also be taken into account; the bread-winner, under existing social conditions, may be unable to give up his work for a sufficient time to give conservative measures a fair trial, and the children of the poor cannot always obtain the necessary attention.

The *local conditions* which decide for or against operation are differently regarded by different surgeons, but it may be said in general terms that operative interference is indicated in cases in which the disease continues to progress in spite of a fair trial of conservative measures; in cases unsuited for conservative treatment—that is to say, where there is dislocation,

separation of epiphysis, or deformity incapable of being otherwise rectified; and where the disease is associated with severe bone lesions. Operative interference is indicated also when the functional result will be better than that likely to be obtained by conservative measures, as is often the case in the knee and elbow. Cold abscesses should, if possible, be dealt with before operating on the joint.

In many cases the nature of the operation can only be decided after exploration. The aim is to remove all the disease with the least possible impairment of function and the minimum sacrifice of healthy tissue. The more open the method of operating the better, so that all parts of the joint may be available for inspection. The methods of Kocher, which permit of dislocating the joint, are specially to be recommended, as this procedure affords the freest possible access. Diseased synovial membrane is removed with the scissors or knife. If the cartilages are sound, and if a movable joint is aimed at, they may be left; but if ankylosis is desired, they must be removed. Localised disease of the cartilage should be removed with the spoon or gouge, and the bone beneath investigated. If the articular surface is extensively diseased, a thin slice of bone should be removed, and if foci in the marrow are then revealed, it is better to gouge them out than to remove further slices of bone, as this involves needless sacrifice of the cortex and periosteum.

The limb should be rendered bloodless before commencing the operation. Every precaution must be taken to prevent tuberculous infection of the wounded surfaces. With the same object, as well as to overcome any minute foci which may have escaped detection, a small quantity of sterilised iodoform, or in children, a paste of iodoform one part and bismuth subnitrate two parts, may be rubbed into the raw surfaces and recesses of the joint.

The terms *arthrectomy* and *excision* are commonly employed to designate the operation performed for the removal of tuberculous disease in a joint. By arthrectomy is meant the removal of diseased synovial membrane and articular cartilage, while excision implies the removal of a portion of one or more of the bones entering into the formation of the joint, along with the entire synovial membrane and cartilage. It should be stated, however, that the original distinction between these procedures has largely disappeared. The modern operation sometimes partakes of the characters of an arthrectomy, sometimes of an excision, but in many cases neither of these

terms would accurately describe the procedure which best meets the requirements of the case. The after-treatment is of considerable importance in order to obtain the maximum usefulness of the limb. When the patient is able to use the limb, the wasting of muscles is likely to be recovered from, and, in young subjects, the growth in length of the bones is resumed.

Operative treatment of deformities resulting from tuberculous joint disease has almost entirely replaced reduction by force; the contracted soft parts are divided, and the bone is resected.

Amputation for tuberculous joint disease has become one of the rare operations of surgery, and is only justified when less radical measures have failed and the condition of the limb is affecting the general health of the patient. Amputation is most frequently called for in persons past middle life, and particularly when septic complications have supervened.

SYPHILITIC DISEASES OF JOINTS

Syphilitic affections of joints are comparatively rare, but it is probable that their frequency has been under-estimated, many cases being incorrectly diagnosed. As in tuberculosis, the disease may be first located in the synovial membrane, or it may spread to the joint from one of the adjacent bones.

In *acquired syphilis*, at an early stage, and before the skin eruptions appear, one of the large joints, such as the shoulder or knee, may be the seat of pain—*arthralgia*—which is worse during the night. Later, a *synovitis* with serous effusion is not uncommon, and may affect several joints. A chronic effusion or *hydrops* is met with almost exclusively in the knee; it is frequently bilateral, and is insidious in its onset and progress, the patient usually being able to go about. Both the synovitis and the hydrops closely resemble the corresponding lesions resulting from gonorrhœa, but they rapidly and completely disappear under anti-syphilitic treatment.

In the *tertiary stage* the joint lesions are more persistent and destructive, and result from the formation of gummata, either in the deeper layers of the synovial membrane or in the adjacent bone or periosteum.

Peri-synovial and *peri-bursal gummata* are met with in relation to the knee-joint of middle-aged adults, especially women. They are usually multiple, develop slowly, and are rarely sensitive or painful. One or more of the gummata

may break down and give rise to tertiary ulcers. Hence the presence of indolent swellings, ulcers, and depressed scars in the vicinity of the knee is to be regarded as characteristic of syphilis.

The gummatous disease may spread throughout the capsule and synovial membrane, which become infiltrated with granulation tissue and diffusely thickened. The granulation tissue may also eat into and replace portions of the articular cartilage. Clinically, the condition closely resembles tuberculous disease of the synovial membrane, for which it is probably frequently mistaken, but in the syphilitic affection the synovial swelling is nodular and uneven, and the subjective symptoms are slight, mobility is little impaired, and yet the deformity is considerable.

Syphilitic osteo-arthritis results from gummata in the periosteum or marrow of the adjacent bones. There is a gradual enlargement of one of the bones, the patient complains of pains, which are worst at night. At this stage the diagnosis from sarcoma may be difficult. The disease may extend to the synovial membrane and be attended with effusion into the joint, or it may erupt on the periosteal surface and invade the skin, forming one or more sinuses. The further progress is complicated by the occurrence of pyogenic infection leading to necrosis of bone. In the knee-joint, the patella, or one of the condyles of the femur or tibia, may furnish a sequestrum. In such cases, anti-syphilitic treatment must be supplemented by operative measures directed to the removal of the diseased tissues. In the knee, excision is rarely called for; but in the elbow it may be performed in order to obtain a movable joint.

In *inherited syphilis* the earliest joint affections are those associated with the epiphysitis of infants, in which there may be an effusion into the adjacent joint, especially in the knee or elbow; and in exceptional cases pyogenic infection may be superadded, and pus form in the joint.

In older children, a gummatous synovitis is met with of which the most striking features are: its insidious development, its chronic course, symmetrical distribution, freedom from pain, the free mobility of the joint, its tendency to relapse, and its association with other syphilitic stigmata, especially in the eye. The knees are the joints most frequently affected, and the condition usually yields readily to anti-syphilitic treatment without impairment of the functions of the joint.

JOINT DISEASES ACCOMPANYING CERTAIN CONSTITUTIONAL CONDITIONS

Gout.—*Arthritis Urica.*—Gout is a disease, one of the manifestations of which is that certain joints are liable to attacks of inflammation associated with the deposit of a chalk-like material composed of sodium bi-urate. This deposit takes place chiefly in the articular cartilage, it may be in streaks or patches towards the central area of the joint, or over the entire extent of the cartilage, which appears as if it had been painted over with plaster of Paris. The urates are really deposited in the substance of the cartilage, and not on its surface. The cartilage is at first intact, but is liable to degenerate and necrose, forming what are known as gouty ulcers, and these may extend through the cartilage and invade the bone. In the synovial membrane the deposit of urates is usually attended with effusion into the joint, while in the ligaments and peri-articular structures it leads to overgrowth of fibrous tissue and the formation of adhesions. The metatarso-phalangeal joint of the great toe, on one or on both sides, is that most frequently affected. The other joints of the foot, and those of the fingers, wrist, ankle, and knee, may also be attacked. The disease is most often met with in men after middle life.

The *clinical features* are characteristic. There is a sudden onset of excruciating pain, usually during the early hours of the morning, the joint becomes tensely swollen, red, and glistening, with engorgement of the veins, and some fever and disturbance of health and temper. In the course of a week or ten days there is a gradual return to the normal. Such attacks recur once a year or oftener, becoming less acute but lasting longer, and the local phenomena tend to persist, the joint remaining permanently swollen and stiff. Masses of chalk form in and around the joint, and those in the subcutaneous tissue may break through the skin, forming indolent ulcers with exposure of the chalky masses—tophi—and until these are extruded or removed the ulcers do not heal. The hands or feet may become seriously crippled, especially when the tendon sheaths and bursæ also are affected.

The local *treatment* consists in employing soothing applications and a Bier's bandage for two or three hours twice daily while the symptoms are acute; later, hot-air baths, massage, and exercises are indicated. It is remarkable how completely even the most deformed joints may recover their functions.

The dietetic and medicinal treatment of gout is to be found in works on Medicine.

Chronic Rheumatism.—The claims of this disease to be called rheumatic rest upon the following data: That it sometimes follows upon acute articular rheumatism; that it may show exacerbations or relapses which are attended with pyrexia and are relieved by salicylates; that it is met with in patients who present a family history of acute rheumatism or of inflammation of serous membranes; and that there may be a history of chorea, erythema nodosum, rheumatic nodules, or other evidences of the rheumatic taint.

The primary changes in the joints involve almost exclusively the synovial membrane and the ligaments; but the surrounding tendon sheaths and bursæ may also be implicated. They consist in cellular infiltration and exudation, resulting in the formation of new connective tissue which encroaches on the cavity of the joint and gives rise to adhesions between the articular surfaces. This newly formed connective tissue tends to contract, causing stiffness and deformity. The articular cartilages may subsequently be transformed into connective tissue, with consequent fibrous ankylosis and complete obliteration of the cavity of the joint. The bones are affected only in so far as they undergo fatty atrophy from disuse of the limb, or alteration in their configuration as a result of partial dislocation. Osseous ankylosis may be observed, especially in the small joints of the hand and foot.

The disease is generally poly-articular and may be met with in childhood and youth as well as in adult life. In some cases pain is so prominent a feature that the patient resists the least attempt at movement. In others, the joints, although stiff, can be moved but exhibit pronounced crackings. When there is much new connective tissue formed in relation to the synovial membrane, the joint is swollen, and as the muscles waste above and below, the swelling is spindle-shaped. Subacute exacerbations occur from time to time, with fever and aggravation of the local symptoms and implication of other joints. Finally, there is ankylosis with deformity, the patient becoming a helpless cripple. On account of the tendency to visceral complications, the tenure of life is uncertain.

From the nature of the disease *treatment* is for the most part palliative. Salicylates are only of service during the exacerbations attended with pyrexia. The application of soda fomentations, turpentine cloths, or electric or hot-air baths may be useful. Improvement may result from the general and

local therapeutics available at such places as Bath, Buxton, Harrogate, Strathpeffer, Wiesbaden, or Aix. In selected cases, a certain measure of success has followed operative interference, which consists in a modified arthrectomy. The deformities resulting from chronic rheumatism are but little amenable to surgical treatment, and forcible attempts to remedy stiffness or deformity are to be avoided.

Arthritis Deformans (*Osteo-arthritis, Rheumatoid Arthritis, Rheumatic Gout, Malum Senile, Traumatic or Mechanical Arthritis*).—Under the term arthritis deformans, which was first employed by Virchow, it is convenient to include a number of joint affections which have many anatomical and clinical features in common.

The morbid changes in the joints present a remarkable combination of atrophy and degeneration on the one hand and overgrowth on the other, indicating a profound disturbance of nutrition in the joint structures. The nature of this disturbance and its true etiology are imperfectly known. There are, however, a number of local conditions, which, by preceding and apparently leading up to the disease, may at least be assumed to have a share in its causation.

Traumatic Lesions of the Joints and of the Articular Ends of Bone.—The condition is frequently observed to follow, either directly or after an interval, upon gross lesions, such as dislocations or fractures, close to the joint. It occurs with even greater frequency on repeated minor injuries affecting the joint and its vicinity, such as sprains and contusions, and particularly those sustained in laborious occupations. This connection between trauma and arthritis deformans led Arbuthnot Lane to apply to it the term *traumatic* or *trade arthritis*.

The traumatic or strain factor in the production of the disease may be manifested in a less obvious fashion. In the lower extremity, for example, *any condition which disturbs the static equilibrium of the limb as a whole* would appear to predispose to the disease in one or other of the joints. The static equilibrium may be disturbed by such deformities as flat-foot, knock-knee, and abnormalities of the pelvis attended with displacement of the acetabulum. Fractures of the lower extremity, also, when badly united, have a similar influence. In hallux valgus, the metatarso-phalangeal joint of the great toe very commonly becomes the seat of changes characteristic of arthritis deformans.

Antecedent Disease of the Joint.—A number of cases have been recorded in which the morbid changes that characterise

arthritis deformans have followed upon infective conditions, such as septic or gonorrhœal synovitis, and upon repeated hæmorrhages into the knee-joint in bleeders.

The above conditions, however, are to be regarded merely as localising factors. To enable them to come into operation, there must either be a constitutional peculiarity predisposing to the disease, the so-called "arthritic diathesis," or some form of auto-intoxication, the toxins presumably being derived by absorption from the gastrointestinal tract.

It is alleged that the disease is met with most frequently in families with rheumatic or gouty tendencies, but while it is true that it may be preceded by attacks of gout or rheumatism, there is no evidence to show that the connection between these diseases is so direct as the terms *rheumatoid arthritis* and *rheumatic gout*, formerly employed, would lead one to believe.

Morbid Anatomy.—The articular cartilage, which at first presents a fibrillated appearance, is gradually worn away as a result of the movements of the joint, until the subjacent bone is exposed. At the margins of the articular surfaces, where the synovial membrane and cartilage meet, there is an active proliferation of cartilage, resulting in nodular projections—*ecchon-droses*—which have been compared in appearance to the droppings from a candle. These tend to be converted into bone, and the ossification thus started may extend into the capsular ligament, thereby adding to the articular margins a collar or "lip"

of new bone, and also into other ligaments and into the insertions of tendons, giving rise to outgrowths of bone—*osteophytes* or *spurious exostoses* (Fig. 267).

The changes which take place within the articular area subsequent to the disappearance of the cartilage vary in different types of the disease. When atrophy with rarefaction of bone is the predominant feature, the enlarged medullary spaces are opened into by the wearing away of the surface layer, and the articular surface of the bone then presents an eroded, worm-eaten appearance. In course of time there may



FIG. 267.—Arthritis Deformans of Elbow, showing destruction of articular surfaces and masses of new bone around the articular margins.

(Anatomical Museum, University of Edinburgh.)

be considerable disappearance of bone and consequent alteration in shape and size—a change which is well illustrated in the progressive enlargement of the acetabulum which takes place in arthritis deformans of the hip. On the other hand, when the bone is condensed and sclerosed, the articular surfaces become smooth and polished, and when this change is very pronounced the appearance may be like that of ivory or porcelain, and is described as *eburnation* of the articular surfaces. In hinge joints, such as the knee or elbow, the eburnated articular surfaces may present a series of parallel grooves corresponding to the lines of friction (Fig. 268). Eburnation has always been ascribed to the polishing of the articular surfaces by the movements of the joint, but as it occurs in joints where movement is inconsiderable, for example

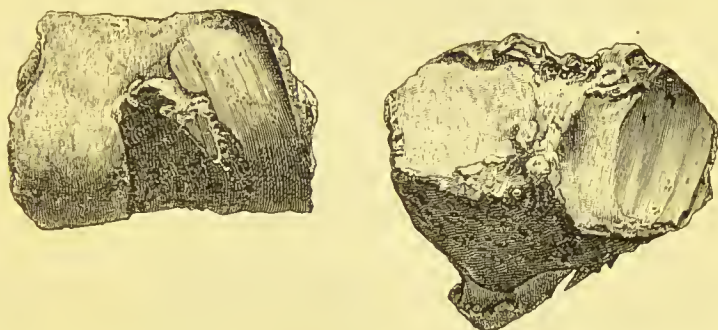


FIG. 268.—Arthritis Deformans of Knee, showing eburnation and grooving of articular surfaces.

(Anatomical Museum, University of Edinburgh.)

the inter-carpal articulations, there must be some other factor in its production.

Although the joint may become locked by the amount of new bone formed around the articular margins, fibrous or bony ankylosis scarcely ever occurs, except in the joints of the vertebral column.

In some cases the synovial membrane merely undergoes a degenerative alteration into cicatricial tissue with a marked tendency to contraction—*arthritis sicca*. In other cases it actively participates in the proliferative changes, becoming more vascular and thickened; and, as the result of hypertrophy of its fringes and enlargement and subdivision of its villi, becomes thickly set with elongated or club-shaped processes which hang into the cavity of the joint (Fig. 269). The term *arborescent lipoma* is applied to the condition when fatty fringes

are developed to an exaggerated degree. Individual fringes may undergo special enlargement and form pendulous growths, in the interior of which cartilage and bone may be formed; these may attain the size of a hazel-nut or even of a walnut. Whether they remain attached to the synovial membrane by their pedicles, or are free, they may give rise to the symptoms of a loose body in the joint. When the synovial changes are



FIG. 269.—Hypertrophied Fringes of Synovial Membrane in Arthritis Deformans of Knee.
(Museum of Royal College of Surgeons, Edinburgh.)

prominent, there is usually considerable serous effusion into the joint, constituting one form of hydrops.

Clinical Features.—It is usually observed that in patients who are still young the tendency is for the disease to advance with considerable rapidity, so that in the course of a few months it may cause serious crippling of several joints. The course of the disease as met with in persons past middle life is more gradual. It begins insidiously, and often many years pass before there is any pronounced disability. The earliest

symptom is stiffness of a joint, especially in the morning after rest, which passes off temporarily with use of the limb. As time goes on, the range of movement becomes restricted, and crackings occur. This stage of the disease may be prolonged indefinitely; if it progresses, stiffness becomes more pronounced, certain movements are lost, others develop in abnormal directions, and the ends of the bones stand out prominently. The disease is compatible with long life, but not with any active occupation.

Hydrops is frequent in the knee, and may be met with in the elbow, shoulder, and ankle; and there may also be hydrops of the adjacent bursæ. As the joint becomes distended with fluid, the ligaments are stretched, so that the limb becomes weak and unstable. The patient complains of a feeling of weight, of insecurity, and of tiredness in the joint. Pain is occasional and evanescent, and is usually the result of some extra exertion, or exposure to cold and wet. This form of the disease is extremely chronic, and may last for an indefinite number of years. It is to be diagnosed from the other forms of hydrops already considered—the purely traumatic, the pyogenic, gonorrhœal, tuberculous, and syphilitic—and from that associated with Chareot's disease.

Fringes and pedunculated or loose bodies, when added to hydrops, give rise to characteristic clinical features, particularly in the knee. The patient may first apply for advice on account of the symptoms of loose body. The fringes, especially when they assume the luxuriance of what has been described as the arborescent lipoma, project into the cavity of the joint, filling up its recesses and distending its capsule. The joint is swollen and slightly flexed. Pain is not a prominent feature, the functions of the joint are but little impaired, and the



FIG. 270.—Arthritis Deformans affecting several joints, in a boy æt. 10.

(Dr. Dickson's case.)

patient may walk fairly well. On grasping the joint while it is being flexed and extended by the patient, the fringes may be felt moving under the fingers.

The *dry form of arthritis deformans* (arthritis sicca), although specially common in the knee, is met with in other joints, either as a mon-articular or poly-articular disease; and it is also very common in the joints of the spine and of the fingers, as well as in the temporo-maxillary joint. In the joints of the fingers in older patients the disease is remarkably symmetrical, and tends to assume a nodular type (Heberden's nodes) (Fig. 271); while in younger subjects it assumes a more crippling, painful, and progressive fusiform type (Fig. 270). In the larger joints the subjective symptoms usually precede any palpable evidence of disease, the patient complaining of stiff-

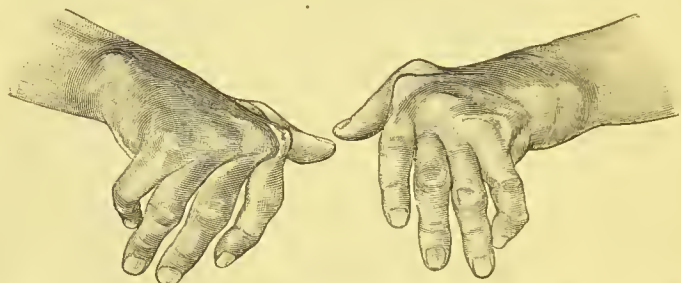


FIG. 271.—Arthritis Deformans of Hands, showing symmetry of lesions, ulnar deviation of fingers, and nodular thickening at inter-phalangeal joints.

ness, crackings, and aching, aggravated by changes in the weather and by rest. The roughness due to fibrillation of the articular cartilages causes coarse friction on moving the joint. It may be months or even years before the lipping and other hypertrophic changes in the ends of the bones are recognisable, and before the joint assumes the deformed features which the name of the disease suggests.

The capsular ligament, except in hydrops, is the seat of connective-tissue overgrowth, and tends to become contracted and rigid. Intra-articular ligaments, such as the ligamentum teres in the hip, are usually worn away and disappear. The surrounding muscles become atrophied, tendons become adherent to their sheaths and may be ossified, and nerves may be involved by the cicatricial changes in the tissues surrounding them.

Treatment.—In the absence of definite knowledge of the

etiology of the disease, treatment is directed towards the relief of symptoms. On no account should the affected joints be kept at rest. Active movements and exercises of all kinds are to be persevered with. When pain is a prominent feature, it may be relieved either by douches of iodine and hot water (tincture of iodine 1 oz. to the quart), or by the application of lint saturated with a lotion made up of chloral hydrate, gr. v, glycerin ʒj, water ʒj, and covered with oil-silk. Strain of the joint and sudden changes of temperature are to be avoided. The induction of hyperæmia by means of massage, the elastic bandage, and hot-air baths is often of great service. Operative interference is only indicated when the disease is of a severe type, when it is mon-articular, and when the general condition of the patient is otherwise favourable. Excision has been practised with success in the hip, knee, elbow, and temporo-maxillary joints. Loose bodies and hypertrophied fringes readily lend themselves to removal by operation.

A course of treatment at one of the reputed spas—Aix, Bath, Buxton, Gastein, Harrogate, Strathpeffer, Wiesbaden, Wildbad—is often of service.

When stiffness and grating on movement are prominent features we have found the injection of from half to one ounce of sterilised white vaseline afford decided relief.

The patient should be nourished well, and there need be no restriction in the diet such as is required in gouty patients, so long as the digestion is not impaired. Benefit is also derived from the administration of cod-liver oil, and of tonics, such as strychnin, arsenic, and iron, and in some cases of iodide of potassium. Luff recommends the administration over long periods of guaiacol carbonate, in cachets beginning with doses of 5–10 grs. and increased to 15–20 grs. thrice daily.

Hæmophilie or Bleeder's Joint. — This is a rare but characteristic affection met with chiefly in the knee-joint of boys who are the subjects of hæmophilia. After some trivial injury, or even without apparent cause, a hæmorrhage takes place into the joint. The joint is tensely swollen, cannot be completely extended, and is so painful that the patient is obliged to lie up. The temperature is often raised (101° to 102° F.), especially if there are also hæmorrhages elsewhere in the body. The blood in the joint is slowly re-absorbed, and in a week or so there is complete return to the normal. In course of time these attacks are repeated; the pain attending them diminishes, but the joint becomes the seat of

permanent changes. The synovial membrane is thickened, abnormally vascular, and coloured brown from the deposit of blood pigment; on its surface, and in parts of the articular cartilage, there is a deposit of rust-coloured fibrin, there may be extensive adhesions, and in some cases changes occur like those observed in arthritis deformans. As the swelling of the joint is associated with wasting of the muscles, with stiffness, and with flexion, the condition may closely resemble tuberculous disease of the synovial membrane. From errors in diagnosis such joints have been operated upon, with disastrous results.

The treatment of a recent hæmorrhage consists in securing absolute rest and applying elastic compression. After an interval, measures should be adopted to promote the absorption of blood and to prevent stiffness and flexion; these include massage, movements, and extension with weight and pulley.

JOINT DISEASES ASSOCIATED WITH LESIONS OF THE NERVOUS SYSTEM : NEURO-ARTHROPATHIES ; SPINAL ARTHROPATHIES ; CHARCOT'S DISEASE

In Lesions of Peripheral Nerves.—In the hand, and more rarely in the foot, when one or other of the main nerve-trunks has been divided or compressed, the joints become swollen and painful, and may afterwards become stiff and deformed. Bony ankylosis has been observed in exceptional cases.

In Affections of the Spinal Cord.—In myelitis, progressive muscular atrophy, poliomyelitis, insular sclerosis, and in traumatic lesions, joint affections are rare, but they are not uncommon in locomotor ataxia and in syringomyelia.

The occurrence of joint lesions in *locomotor ataxia* (tabes dorsalis) was first described by Charcot in 1868—hence the term “Charcot's disease” applied to them. Although they usually develop in the ataxic stage, one or more years after the initial spinal symptoms, they may appear before there is any other evidence of tabes. The onset is frequently determined by some injury to the joint. The joints of the lower extremity are most commonly affected, and the disease is bilateral in a considerable proportion of cases—both knees or both hips, for instance, being implicated (Fig. 292).

The first symptom is usually a swelling of the joint and its vicinity, often over a wide extent. There is no redness or heat, and no pain on movement. The peri-articular swelling, unlike ordinary œdema, scarcely pits even on firm pressure.

In mild cases this condition of affairs may persist for months; in severe cases destructive changes ensue with remarkable rapidity. The joint becomes enormously swollen, loses its normal contour, and the ends of the bones become irregularly deformed (Fig. 272). Sometimes, and especially in the knee, the clinical features are those of an enormous hydrops with fibrinous and other loose bodies and hyper-trophied fringes—and great œdema of the peri-articular tissues (Fig. 273). The joint is wobbly or flail-like from the stretching and destruction of the controlling ligaments, and is devoid of sensation. In other cases, wearing down and total disappearance of the ends of the bones is the prominent feature, attended with flail-like movements and with coarse grating in the joint. Dislocation is observed chiefly at the hip (Fig. 292), and is rather a gross displacement with exaggerated mobility than a typical dislocation, and it is usually possible to move the bones freely upon one another. An occasional and very striking feature is the extensive development of new bone in the capsular ligament and surrounding muscles, resulting in the formation of large masses and plates of bone which may add materially to the already existing deformity. In certain cases the enormous swelling and its rapid development may suggest the growth of a malignant tumour. The most useful factor in diagnosis is the entire absence of pain, of tenderness, and of common sensibility. The freedom with which a tabetic patient will allow his disorganised joint to be handled requires to be seen to be appreciated.



FIG. 272.—Bones of Knee-joint in advanced stage of Charcot's Disease. The inner part of the head of the tibia has entirely disappeared.

(Anatomical Museum,
University of Edinburgh.)

The rapidity of the destructive changes in certain cases

of tabes, and the entire absence of joint lesions in others, would favour the view that special parts of the spinal cord must be implicated in the former group.

In *syringomyelia*, joint affections (gliomatous arthropathies) are more frequent than in tabes, and they usually involve the upper extremity in correspondence with the seat of the spinal lesion, which usually affects the lower cervical and upper dorsal segments of the cord (Fig. 278). Except that

the joint disease is seldom symmetrical, it closely resembles the arthropathy of tabes. The completeness of the analgesia of the articular structures and of the overlying soft parts is well illustrated by the fact that in one case the patient himself was in the habit of letting out the fluid from his elbow with the aid of a pair of scissors, and that in another the joint was painlessly excised without an anæsthetic.

The disease may become arrested or may go on to complete disorganisation of the joint; supuration may ensue from infection through a breach of the surface, and in rare cases the joint has become the seat of tuberculous.

Treatment, apart from that of the nerve lesion underlying the arthropathy, consists in supporting and protecting the joint by means of bandages, splints, and other apparatus. In the lower extremity, the use of crutches is helpful in taking the strain off the affected limb. When there is much distension of the joint, considerable relief may follow withdrawal of fluid. The best possible result being rigid ankylosis in a good position, it may be advisable to bring this about artificially by arthrodesis or resection, when only one joint is affected and



FIG. 273.—Charcot's Disease of Left Knee. The joint is distended with fluid and the whole limb is œdematous.

when the cord lesion is such as will permit of the patient moving about. The wounds heal well, but the victims of tabes are unfavourable subjects for operative interference, on account of their liability to intercurrent complications. When the limb is quite useless, amputation may be the best course.

In cerebral lesions attended with hemiplegia, joint affections, characterised by evanescent pain, redness, and swelling, are occasionally met with in the paralysed limbs. The secondary



FIG. 274.—Charcot's Disease of Left Knee-joint.
(Photograph lent by Mr. J. M. Cotterill.)

changes in joints which are the seat of paralytic contracture are considered with Deformities.

An intermittent neuropathic hydrops has been observed—especially in the knee—in cases of hysteria and other functional affections of the nervous system. Without apparent cause, the joint fills with fluid and its movements become restricted, and after from two to eight days the swelling subsides and the joint returns to normal. A remarkable feature of the

condition is that the effusion of the joint recurs at regular intervals, it may be over a period of years. Psychic conditions have been known to induce attacks, and sometimes to abort them or even to cause their disappearance. Hence it has been recommended that treatment by suggestion should be employed along with tonic doses of quinine and arsenic.

HYSTERICAL OR MIMETIC JOINT AFFECTIONS

Under this heading, Sir Benjamin Brodie, in 1822, described an affection of the joints, characterised by the prominence of subjective symptoms and the absence of pathological changes. Although most frequently met with in young women with an impressionable nervous system, and especially among those in good social circumstances, it occurs occasionally in men. The onset may be referred to injury or exposure to cold, or may be associated with some disturbance of the emotions, or with disease of the generative organs; or the conditions may be an involuntary imitation of the symptoms of organic joint disease presented by another patient.

It is characteristic that the symptoms develop abruptly without sufficient cause, that they are exaggerated and wanting in harmony with one another, and that they do not correspond with the typical features of any of the known forms of organic disease. In some cases the only complaint is of severe neuralgic pains; more often these are associated with excessive tenderness, and with impairment of the functions of the joint. On examination the joint presents a normal appearance, but the skin over it is remarkably sensitive. A light touch is more likely to excite pain than deep and firm pressure. Stiffness is a variable feature—in some cases amounting to absolute rigidity, so that no ordinary force will elicit movement. It is characteristic of this, as of other neuroses, that the symptoms come and go without apparent cause. When the patient's attention is diverted, the pain and stiffness may disappear. There is never any actual swelling of the joint, although there may be an appearance of this from wasting of the muscles above and below. If the joint is kept rigid for long periods, secondary contracture may occur—in the knee with flexion, in the hip with flexion and adduction—and attempts at movement may then cause cracking.

The *diagnosis* is often a matter of considerable difficulty, and the condition is liable to be mistaken for such organic lesions as a tuberculous or pyogenic focus in the bone close to a joint,

which may cause vague neuralgic pains for long periods before rupturing into the articulation. The greatest difficulty is met with in the knee and hip, where the condition may closely simulate tuberculous disease. The use of the Röntgen rays, or examination of the joint under anæsthesia, are to be had recourse to in difficult cases.

The *local treatment* consists chiefly in improving the nutrition of the affected limb by means of massage, exercises, baths, and electricity. Splints are to be avoided. In refractory cases, considerable benefit may follow the application of Corrigan's button or the actual cautery. The general condition of the patient must be treated on the same lines as in other neuroses. The Weir-Mitchell treatment may have to be employed in obstinate cases, the patient being secluded from her friends and placed in charge of a nurse. Complete recovery is the rule, but when the muscles are weak and wasted from prolonged disuse, a considerable time may elapse before the limb returns to normal.

TUMOURS AND CYSTS

New-growths taking origin in the synovial membrane are very rare, and are not usually diagnosed before the joint is opened. They are frequently attended with an exudation into the joint, and in the case of *sarcomata* the fluid is usually blood-stained. If the tumour projects in a polypoidal manner into the joint, it may cause symptoms of loose body. One or two cases have been recorded in which a *cartilaginous tumour* growing from the synovial membrane has erupted through the joint capsule and infiltrated the adjoining muscles. *Multiple cartilaginous tumours* forming loose bodies in the joint are described on p. 732.

Cysts of joints constitute an ill-defined group which includes ganglia formed in relation to the capsular ligament. Cystic distension of bursæ which communicate with the joint is most often met with in the region of the knee in cases of long-standing hydrops. It was suggested by Marrant Baker that similar cystic swellings may result from the hernial protrusion of the synovial membrane between the stretched fibres of the capsular ligament, and the name "Baker's cysts" has been applied to these.

In the majority of cases, cysts in relation to joints give rise to little inconvenience and may be left alone. If interfered with at all, they should be excised.

LOOSE BODIES

While there is considerable difference of opinion as to the origin and nature of loose bodies, their clinical aspects and treatment are clear and straightforward. It is convenient to describe the varieties of loose bodies under two heads: those composed of fibrin, and those composed of organised connective tissue.

Fibrinous Loose Bodies (*corpora oryzoidea*).—These are homogeneous or concentrically laminated masses of fibrin, sometimes resembling rice grains, melon seeds, or adhesive wafers, sometimes quite irregular in shape. Usually they are present in large numbers, but sometimes there is only one, and it may attain considerable dimensions. They are not peculiar to joints, for they are met with in tendon sheaths and bursæ, and their origin from synovial membrane may be accepted as proved. They occur in tuberculosis, arthritis deformans, and in Charcot's disease, and their presence is almost invariably associated with an effusion of fluid into the joint. While they may result from the coagulation of fibrin-forming elements in the exudate, their occurrence in tuberculous hydrops would appear to be the result of coagulation necrosis, or of fibrinous degeneration of the surface layer of the diseased synovial membrane. However formed, their shape is the result of mechanical influences, and especially of the movement of the joint.

Clinically, loose bodies composed of fibrin constitute an unimportant addition to the features of the disease with which they are associated. They never give rise to the classical symptoms associated with impaction of a loose body between the articular ends of the bones. Their presence may be recognised, especially in the knee, by the crepitating sensation imparted to the fingers when the bodies are moved to and fro in the fluid.

The *treatment* is directed towards the disease underlying the hydrops. If it is desired to empty the joint, this is best done by means of an incision.

Bodies composed of Organised Connective Tissue.—These are comparatively common in joints which are already the seat of some chronic disease, such as arthritis deformans, Charcot's arthropathy, or synovial tuberculosis. They take origin almost exclusively from an erratic overgrowth of the fringes of the synovial membrane, and may consist entirely of fat, the arborescent lipoma (Fig. 269) being the most remarkable ex-

ample of this variety. Fibrous tissue or cartilage may form in one or more of the fatty fringes and give rise to hard nodular masses, which may attain a considerable size, and in course of time may undergo ossification (Fig. 275).

Like other hypertrophies on a free surface, they tend to become pedunculated, and so acquire a limited range of movement. The pedicle may give way and the body become free. In this condition it may wander about the joint, or lie snugly in one of its recesses until disturbed by some exaggerated movement. It is alleged that a loose body free in a joint is capable of growth, deriving the necessary nutriment from the surrounding fluid. The size and number of the bodies vary widely. Single specimens have been known to attain the size of the patella. The smaller varieties may number considerably over a hundred.

In arthritis deformans a rarer type of loose body is met with, a portion of the lipping of one of the articular margins being detached by injury. In Charcot's disease, bodies composed of bone may be formed in relation to the capsular and other ligaments, and can be made to grate upon one another.

The *clinical features* in this group are mainly those of the disease which has given rise to the loose bodies, and it is exceptional to meet with definite symptoms from impaction of a body between the articular surfaces. Treatment is to be directed towards the primary disease in the joint, as well as to the removal of the loose bodies.

Loose Bodies in Joints which are otherwise healthy.—It is in joints otherwise healthy that loose bodies causing the classical symptoms and calling for operative treatment are most frequently met with. They occur chiefly in the knee and elbow of healthy males under the age of thirty. The complaint may be of vague pains, which are ascribed to rheumatism, of occasional cracking on moving the joint, or of impairment of function—usually an inability completely to extend or flex the joint. In many cases a clear account is given of the characteristic symptoms which arise when the body is impacted between the articular surfaces, namely, sudden onset of intense sickening pain, loss of power in the limb and locking of the joint, followed

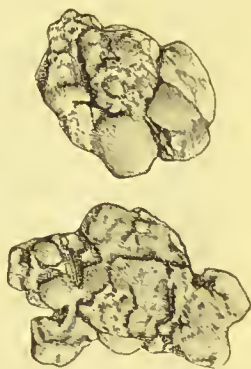


FIG. 275.—Loose Bodies from Knee-joint, consisting of cartilage and bone.

(Anatomical Museum, University of Edinburgh.)

by effusion and the other accompaniments of a severe sprain. On making some particular movement of the joint, the body may be disengaged, the locking disappear, and recovery take place, as after a sprain. Attacks of this kind may recur at irregular intervals during a period of many years. On examining the joint, it is usually found to contain fluid, and there may be points of special tenderness corresponding to the ligaments that have been sprained. The patient himself, or the surgeon, may be able to palpate the loose body and feel it roll beneath his fingers, especially if it is lodged in the suprapatellar pouch in the knee, or on one or other side of the olecranon in the elbow. In most instances the patient has

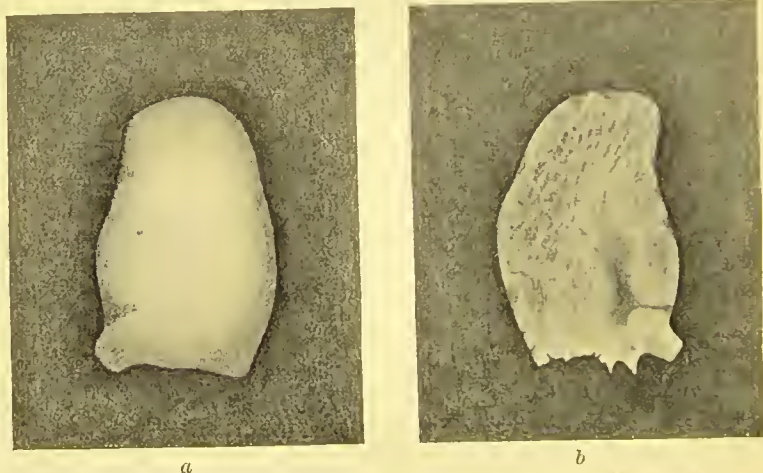


FIG. 276.—Loose Body from Knee-joint of man æt. 25. Natural size.

a = Convex surface. *b* = Concave surface.

carefully observed his own symptoms, and is aware not only of the existence of the loose body, but of its situation when attached, or of its erratic appearance at different parts of the joint when free. When the body contains bone, it may be visible in a skiagram. While in some cases the patient attributes his symptoms to an injury, exactly similar phenomena may occur apart altogether from traumatic influences. The treatment consists in opening the joint and removing the loose body.

The characters of these loose bodies are remarkably constant. They are usually solitary, about the size of a bean or almond, concavo-convex in shape, the convex aspect being smooth like an articular surface, the concave aspect more often uneven and

nodulated (Fig. 276). Such bodies may be lodged in a kind of compartment or excavation in one of the articular surfaces, usually the inner condyle of the femur, close to the attachment of the posterior cruciate ligament, from which they may be readily shelled out by means of an elevator. They usually present on section a nucleus or core of spongy bone or of calcified cartilage.

As to the origin of these bodies, some maintain that they result from the detachment by injury of a portion of the

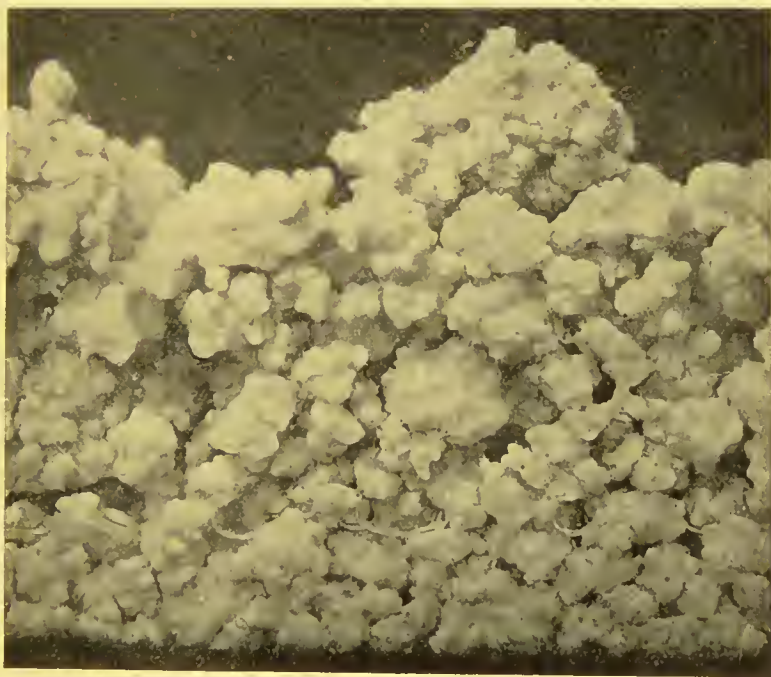


FIG. 277.—Multiple Chondromata of Synovial Membrane, from Knee-joint.

articular surface, while König regards them as portions of the articular surfaces which have been detached by a morbid process which he calls “osteochondritis dissecans.”

Multiple Chondromata of the Synovial Membrane.—In this rare type of loose body, the surface of the synovial membrane is studded over with small sessile or pedunculated tumours composed of pure hyaline cartilage. They are pearly white in colour, pitted and nodular on the surface, rarely larger than a pea, although when compressed they may cake into masses of considerable size. With the movements of the joint many

of the tumours become detached and lie in the serous exudate excited by their presence.

The patient complains of increasing disability of the limb, movements of the joint becoming more and more restricted and painful. There is swelling corresponding to the distended capsule of the joint, and on palpation the bodies moving under the fingers yield a sensation as of grains of rice shifting in a bag. If the bodies are so numerous as to be tightly packed together, the impression is that of a solid mass having the shape of the synovial sac. We have observed two cases of this affection, both in the knee-joint of adult women; the removal of the loose bodies (Fig. 277) by open operation resulted in a useful joint.

Displacement of the semilunar cartilages in the knee is referred to with injuries of that joint (p. 593).

CHAPTER XXX

DISEASES OF INDIVIDUAL JOINTS

THE SHOULDER-JOINT

THE shoulder is seldom the seat of disease, and most affections of the joint are met with in adults. In young subjects, infective processes result chiefly from extensions of disease from the upper epiphysial junction of the humerus, which is partly included within the limits of the synovial cavity. The synovial membrane, in addition to lining the capsular ligament, is prolonged down the bicipital groove around the long tendon of the biceps, and pus may escape from the joint by this diverticulum and gravitate down the arm. There is frequently a communication between the joint and the sub-deltoid bursa. There is no characteristic attitude in disease of the shoulder-joint, but the girdle is usually elevated, the upper arm held close to the side and rotated slightly inwards, while the elbow is carried a little backwards. In the later stages, the head of the humerus may be drawn upwards and inwards towards the coracoid process. Fixation of the shoulder-joint is largely compensated for by free movement of the scapula on the thorax, so that when testing for rigidity the scapula should be fixed with one hand, while passive movements of the arm are carried out with the other. The deltoid is usually atrophied, allowing the acromion, coracoid, and great tuberosity of the humerus to stand out prominently beneath the skin. Swelling is rarely a prominent feature, except when there is a collection of fluid or an abscess in the bursa beneath the deltoid.

Tuberculous Disease.—This is usually met with in young adults, and is more common in the right shoulder. The prominent features are pain, rigidity, and wasting of the deltoid and scapular muscles. The pain is sometimes severe, shooting down the arm and interfering with sleep, and it may be

associated with tenderness on pressure over the upper end of the humerus. In cases with carious destruction of the articular surfaces, there are starting pains, and the upper arm is shortened. If a cold abscess forms in the bursa underneath the deltoid, the pus may burrow and appear at the anterior or posterior boundary of the axilla or in the axillary space. Pus formed in the joint tends to gravitate along the bicipital groove. The axillary glands may be infected.

The pathological lesion is either a large caseating focus in one of the bones—most often in the upper end of the humerus—or it is of the nature of *caries sicca*. The greater part of the head may disappear, and the upper end of the shaft be drawn against the socket. In exceptional cases, portions of the glenoid or humerus are found separated as sequestra, or the disease involves parts outside the joint, such as the acromion or coracoid process. Hydrops with melon-seed bodies is rare. In young subjects, destruction of the tissues at the ossifying junction may result in considerable shortening of the upper arm.

The *diagnosis* is to be made from (1) arthritis deformans, in which the movements are less restricted, and are attended with grating and crackling; (2) paralysis involving the deltoid and scapular muscles—by the absence of pain, and the flail-like character of the movements; (3) disease in the sub-deltoid bursa—by the absence of rigidity and other evidence of implication of the articular surfaces; and (4) sarcoma of the upper end of the humerus—by the history of the case, the use of the X-rays or an exploratory incision.

While the *prognosis* is favourable on the whole, spontaneous recovery is usually attended with fibrous ankylosis and incapacity to raise the arm above the level of the shoulder. The disease is often very persistent, and may last for several years.

Treatment.—The limb should be immobilised in the position of abduction with the forearm and hand directed forwards; the most efficient apparatus is a plaster spica embracing the thorax and the upper limb down as far as the wrist. If the articular surfaces are affected and the disease is likely to lead to ankylosis, the arm should be abducted to a right angle. Severe pain may be relieved by blistering or by the application of the cautery. To inject iodoform, the needle is introduced either immediately outside the coracoid process, or just below the junction of the acromion process and spine of the scapula. When the disease does not yield to conservative measures, or the X-rays show a gross lesion in the bone, excision of the

joint should be performed; a close fibrous ankylosis usually results, and the arm is quite a useful one.

Pyogenic Diseases.—The shoulder-joint may be infected by extension of suppurative osteomyelitis from the upper end of the humerus, or from suppuration in the axilla, or through the blood-stream by ordinary pus organisms, pneumococci, typhoid bacilli, or gonococci. Extension should be applied to the upper arm abducted at a right angle. When it is necessary to drain the joint, the incision should be placed anteriorly in the line

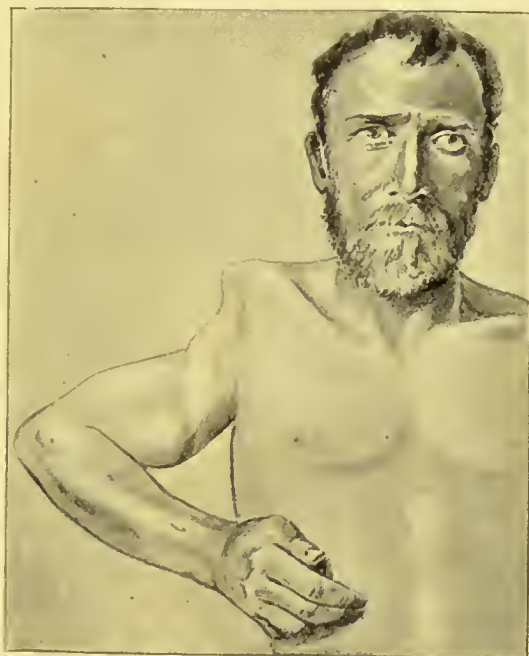


FIG. 278.—Arthropathy of Shoulder in Syringomyelia. The upper end of the humerus has disappeared and the movements are flail-like (cf. Fig. 279).

of the bicipital groove, and a counter-opening made on the posterior aspect by cutting on the point of a dressing forceps introduced through the anterior incision.

Arthritis Deformans.—The shoulder is seldom affected alone, except when the arthritis is a sequel to injury. The common type of lesion is a dry arthritis with fibrillation and eburnation of the articular surfaces. The long tendon of the biceps is usually destroyed, and the head of the bone is drawn upwards, and, after wearing through the capsule, rubs on the under sur-

face of the acromion. The clinical features are pain, stiffness, and crackling on movement.

Neuro-arthropathies of the shoulder are met with chiefly in



FIG. 279.—Radiogram of Arthropathy of Shoulder in Syringomyelia. The head of the humerus has disappeared and masses of new bone have formed in the surrounding muscles (cf. Fig. 278).

(Radiogram by Dr. Hope Fowler.)

syringomyelia. The clinical features may be a large fluctuating and painless swelling, or marked and rapid wasting of the deltoid and scapular muscles with flail-like movements of the joint, associated with disappearance of the upper end of the humerus (Fig. 278).

Ankylosis is not so disabling at the shoulder as at other joints, as the mobility of the scapula on the chest wall largely compensates for the fixation of the joint.

THE ELBOW-JOINT

In disease of the elbow, the usual attitude is that of flexion with pronation of the hand. Swelling of the joint, whether from effusion of fluid or from thickening of the synovial membrane, is observed chiefly on the posterior aspect, above and on either side of the olecranon, because the synovial sac is here nearest the surface. The free communication between the elbow and the superior radio-ulnar joint should be borne in mind.

Tuberculous disease is the most common and important affection of the elbow (Fig. 280). It usually occurs in patients under twenty, but may be met with at any age, and even in old people. When the disease is confined to the synovial membrane, its onset is insidious, there is little or no pain, and no interference with any movement except complete extension. The chief evidence of disease is a white swelling on either side of and above the olecranon, obscuring the bony landmarks. The further progress is attended with wasting of the triceps, symptoms of involvement of the articular surfaces, and with abscess formation.

The occurrence of articular caries without swelling of the synovial membrane is exceptional, and is associated with a good deal of pain and considerable restriction of movement. Rigidity from muscular contraction occurs late, and is rarely complete. Tuberculous foci in the bones are met with chiefly in the upper



FIG. 280.—Diffuse Tuberculous Thickening of Synovial Membrane of Elbow (white swelling) in a boy *et.* 12.

end of the ulna and the lower end of the humerus; they may be recognised by swelling, and pain on making pressure over the bone. The grosser osseous lesions cause enlargement of the bone, and are readily demonstrated by skiagraphy. Abscess formation most commonly occurs beneath the triceps, and the abscess points at one or other edge of that muscle. A sub-



FIG. 281.—Contracture of Elbow and Wrist following a burn in childhood. Treated by resection of both joints, and the insertion, on the palmar aspect of each, of a flap from the abdominal wall.

cutaneous abscess may form over the upper end of the ulna or over the radio-humeral joint. Tuberculous hydrops with melon-seed bodies is rare.

Treatment.—Conservative measures are persevered with so long as there is a prospect of securing a movable joint. The limb is placed in a Thomas' or a poroplastie splint reaching from the axilla to the wrist, flexed to rather less than a right

angle and with the hand semi-pronated. To inject iodoform, the needle of the syringe is most easily introduced between the external condyle and the head of the radius. A localised focus of disease in one or other of the bones may be eradicated without opening into the synovial cavity.

If the articular surfaces are so involved that recovery is likely to be attended with ankylosis, the disease should be removed by arthrectomy or excision, and cure of the disease with a useful and movable limb may then be reasonably anticipated within two or three months. When the patient's occupation is such that a strong, stiff joint is preferable to a weaker movable one, bony ankylosis at rather less than a right angle should be aimed at.

Arthritis deformans occurs as a hydrops with hypertrophy of the synovial fringes and loose bodies, or as a dry arthritis with eburnation and lipping of the articular margins.

Neuro-arthropathies are met with chiefly in syringomyelia, and are attended with striking alterations in the shape of the bones and with abnormal mobility.

Pyogenic diseases result from staphylococcal osteomyelitis—chiefly of the humerus or ulna—and from gonorrhœa.

The remaining diseases at the elbow include syphilitic disease in young children, bleeder's joint, hysterical affections, and loose bodies, and do not call for special description.

Ankylosis of the elbow-joint, if interfering with the livelihood of the patient, may be got rid of by resecting the articular ends of the bones, or by inserting between them a flap of fascia and subcutaneous fat derived from the posterior aspect of the upper arm—*arthroplasty*.

THE WRIST-JOINT

The close proximity of the flexor sheaths to the carpal articulations enables infective processes to spread readily from one to the other. The arrangement of the synovial membrane also favours the extension of disease throughout the numerous articulations in the region of the wrist.

Tuberculous disease is met with chiefly in young adults, but may occur at any age. It usually originates in the synovial membrane, but foci are frequently present in the carpal bones, and less commonly in the lower ends of the radius and ulna, or in the bases of the metacarpals. The clinical features are almost invariably those of white swelling, which is most marked on the dorsum, where it obscures the bony prominences and

the outlines of the extensor tendons. Wasting of the thenar and hypothenar eminences, and filling up of the hollows above and below the anterior annular ligament, render the appearance on the palmar aspect very characteristic.

The attitude is one of slight flexion with drooping of the hand and fingers. The fingers become stiff as a result of adhesions in the tendon sheaths, and the power of opposing the thumb and fingers may be lost. Pain is usually absent until the articular surfaces become carious. Softening of the ligaments may result in lateral mobility and sometimes in partial dislocation. Abscess may be followed by the formation of sinuses, and infection of the tendon sheaths, especially those in the palm.

The exact localisation of disease in individual bones or joints may be determined by the position of pain elicited on pressure or movement, and by the use of the X-rays.

Treatment.—Conservative measures may be persevered with over a longer period than in most other joints. The forearm, wrist, and metacarpus are immobilised in the attitude of dorsal flexion of the hand, while the fingers and thumb are left free to allow of passive movements. It may be necessary to give an anæsthetic to obtain the necessary degree of dorsiflexion. To inject iodoform, the needle is inserted immediately below the radial or the ulnar styloid process. Sometimes the carpal bones are so soft that the needle can be made to penetrate them in different directions. Operative treatment is indicated in cases which resist conservative measures, or when the general health calls for removal of the disease. Excision of the diseased bones and synovial membrane by a single ulnar incision (Heron Watson) does not leave a disfiguring scar, and usually yields a movable joint.

Other diseases of the wrist are comparatively rare. They include pyogenic affections, such as those resulting from septic conditions in the palm of the hand, different types of gonorrhœal, rheumatic, and gouty affections, and arthritis deformans.

THE HIP-JOINT

Owing to the depth of this joint from the surface, it is not possible to detect the presence of effusion or of synovial thickening as readily as in other joints, hence in the recognition of hip disease we have to rely very largely upon indirect evidence, such as a limp in walking, an alteration in the attitude of the limb, or restriction of the normal movements of the joint. In

examining a case of suspected hip disease, it is necessary to compare the length of the two limbs, to ascertain the position of the great trochanter in relation to Nélaton's line, to recognise the attitude of the limbs in relation to the pelvis, and to note whether or not the pelvis is tilted.

It should be borne in mind that the whole of the anterior and fully one-half of the posterior aspect of the neck of the femur is covered by synovial membrane, so that lesions not only of the epiphysis and epiphysial junction, but also of the neck of the bone, are capable of extending directly to the synovial membrane and to the cavity of the joint. Infective material may escape from the joint into the surrounding tissues through any weak point in the capsule, particularly through the bursa which intervenes between the capsule and the ilio-psoas, and which in one out of every ten subjects communicates with the joint.

TUBERCULOUS DISEASE

Tuberculous disease of the hip, *morbus coxæ*, or "hip-joint disease," is especially common in the poorer classes. It is a frequent cause of prolonged invalidism and of permanent deformity, and is attended with a considerable mortality. It is essentially a disease of early life, rarely commencing after puberty, and almost never after maturity.

Pathological Anatomy.—Bone lesions bulk more largely in hip disease than they do in disease of other joints—five cases originating in bone to one in synovial membrane. The upper end of the femur and the acetabulum are affected with about equal frequency.

In addition to primary tuberculous lesions, secondary changes result from the inflamed and softened bones pressing against one another, subsequent to the destruction of their articular cartilages. The head of the femur undergoes absorption from above downwards, becoming flattened and truncated, or disappearing altogether. In the acetabulum the absorption takes place in an upward and backward direction, whereby the socket becomes enlarged and elongated towards the dorsum ilii. To this progressive enlargement of the socket Volkmann gave the suggestive name of "wandering acetabulum" (Fig. 282). The displacement of the femur resulting from these secondary changes is one of the causes of real shortening of the limb in advanced cases of hip disease.

Clinical Features.—It is customary to describe three stages

in the progress of hip disease, but it is to be borne in mind that these merge into one another.

Initial Stage.—At this stage the disease is confined either to the synovial membrane, or to a focus in the bone which has not yet opened freely into the cavity of the joint. The onset is usually insidious, and if injury is alleged as an exciting cause, some weeks have usually elapsed between the receipt of the injury and the onset of symptoms. In the case of a child, he is usually brought for advice because he has begun to limp and to suffer pain. There is a history that he has become pale, that he has ceased to take food well, that his sleep has been disturbed, and that the pain and the limp, after coming and going for a time, have become more continuous and pronounced. On walking, the affected limb is dragged in such a way as to avoid movement at the hip, and to substitute for it movement at the lumbo-sacral junction. The child throws the weight of the trunk as little as possible on to the affected limb, and inclines to rest on the balls of the toes rather than on the heel. There is usually some wasting of the muscles of the thigh and flattening of the buttock. Diminution or



FIG. 282.—Advanced Tuberculous Disease of Acetabulum with caries and perforation into pelvis.

(Anatomical Museum, University of Edinburgh.)

loss of the gluteal fold indicates a degree of flexion at the hip which might otherwise escape notice. Pain is complained of in the hip, or is referred to the inner side of the knee, in the distribution of the obturator nerve. Sometimes the pain is confined to the knee, and if the examination is restricted to that joint the disease at the hip may be overlooked. At this stage the attitude of the limb is not constant; at one time it may be quite natural, and at another slightly

flexed and abducted. Tenderness of the joint may be elicited by pressing either in front or behind the head of the bone, but is of little diagnostic importance. Pain elicited on driving the head against the acetabulum may occasionally assist in the recognition of hip disease, but the diagnostic value of this sign has been over-rated.

Most information is gained by testing the functions of the joint, and if this is done gently and without jerking, there is no complaint of pain. The child should lie on his back, either on his nurse's knee or on a table; and to reassure him the movements should be first practised on the sound limb. On slowly flexing the thigh of the affected limb, it will be found that the range of flexion at the hip is soon exhausted, and that any further movement in this direction takes place at the lumbo-sacral junction. The child is next made to lie on his face with the knees flexed in order to test the movements of rotation. The thigh is rotated outwards and inwards, and on comparing the two sides it will be found that rotation is restricted or abolished on the side affected, any apparent rotation taking place at the lumbo-sacral junction. These tests reveal the presence of *rigidity* resulting from the involuntary contraction of muscles, which is the most reliable sign of hip disease during the initial stage. This procedure has the advantage of being universally applicable, even in the case of very young children.

Second Stage.—This probably corresponds with commencing disease of the articular surfaces, and progressive involvement of all the structures of the joint. The patient presents more evident symptoms, and usually exhibits the attitude of abduction, eversion, and flexion (Fig. 283) which, although characteristic of the second stage of the disease, is not constant; one or other of the abnormal attitudes may predominate or may be entirely wanting.

At first the attitude is maintained entirely by the action of muscles; but when it is prolonged, the muscles, fasciæ, and ligaments undergo shortening, so that it becomes fixed.

On looking at the patient, the abnormal attitude may not be at once evident, as he usually restores the parallelism of the limbs by lowering the pelvis on the affected side and adducting the sound limb. This obliquity or tilting of the pelvis causes *apparent lengthening* of the diseased limb. It is best demonstrated by drawing one straight line between the anterior iliac spines, and another to meet it from the ensiform cartilage through the umbilicus. If the pelvis is in its normal position,

the two lines intersect at right angles ; if it is tilted, the angles at the point of intersection are unequal. The flexion may be largely compensated for by increasing the forward curve of the lumbar spine (lordosis), and by flexing the leg at the knee. There may also be an attempt to compensate for the eversion of the limb by rotating the pelvis forwards on the affected side. To demonstrate the lordosis, the patient should be laid on a



FIG. 283.—Early Tuberculous Disease of Right Hip-joint in a boy *æt.* 14, showing flexion, abduction, and apparent lengthening of the limb.

flat table ; in the resting position, the lordosis is moderate, when the hip is flexed it disappears, when it is extended the lordosis is exaggerated, and the hand or closed fist may be inserted between the spine and the table (Figs. 284, 285).

When *the functions of the joint* are tested, it will be found that there is rigidity, and that both active and passive movements take place at the lumbo-sacral junction instead of at the

hip. While rigidity is usually absolute as regards rotation, it may sometimes be possible with care and gentleness to obtain a little increase of flexion. For diagnostic purposes most stress should therefore be laid on the absence of rotation—for example, a patient who exhibits abduction and flexion, and yet admits of movements of rotation being carried out, probably is not suffering from disease of the hip-joint but from some affection in its neighbourhood.

The “Thomas’ flexion test” is founded upon the inability to extend the diseased hip without producing lordosis.

If the sound limb is flexed at the hip and knee until the lumbar spine is in contact with the table, the real flexion of the diseased hip becomes manifest, and may be roughly

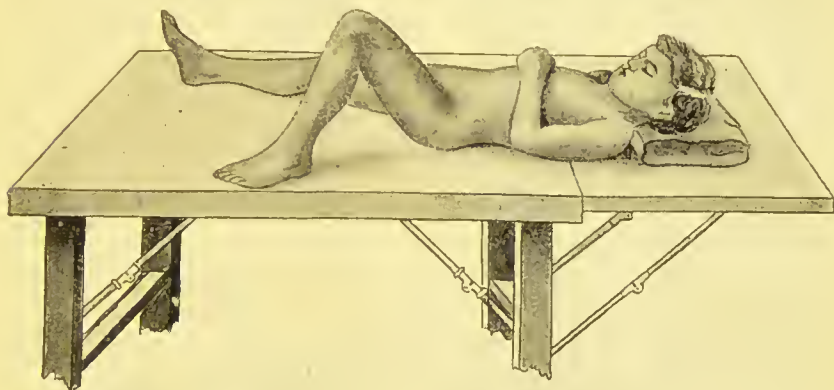


FIG. 284.—Disease of Left Hip—disappearance of lordosis on flexion of the hip.

measured by observing the angle between the thigh and the table (Fig. 286).

Swelling is best detected on the anterior aspect of the joint; when present, it may fill up the fold of the groin and push forward the femoral vessels. It is doughy and elastic, like the white swelling of other joints, but may at any time liquefy and form a cold abscess. Swelling about the trochanter and neck of the bone may be estimated by measuring the antero-posterior diameter with calipers, and comparing with the sound side. The absence of swelling does not, however, exclude the existence of hip disease. Swelling on the pelvic aspect of the acetabulum may be discovered on rectal examination.

Third Stage.—This probably corresponds with advanced

caries of the articular surfaces, since pain is now a prominent feature, and there are usually startings at night. The

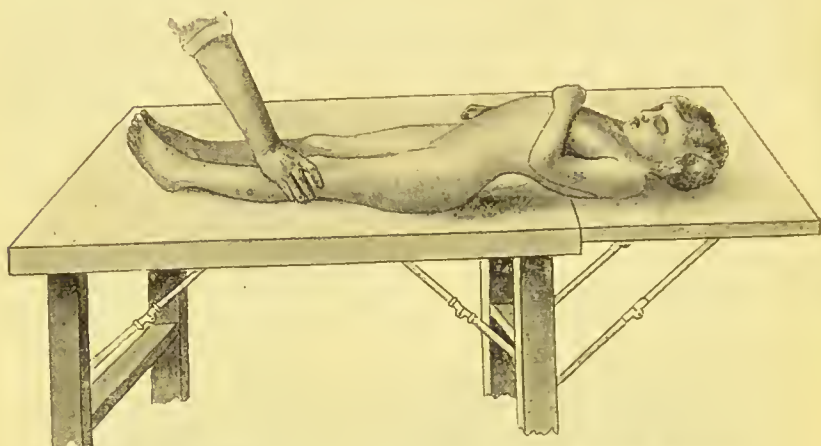


FIG. 285.—Disease of Left Hip—exaggeration of lordosis produced by extending the joint.

attitude is one of *adduction, inversion, flexion, and apparent or real shortening of the limb* (Fig. 287). The *flexion* is

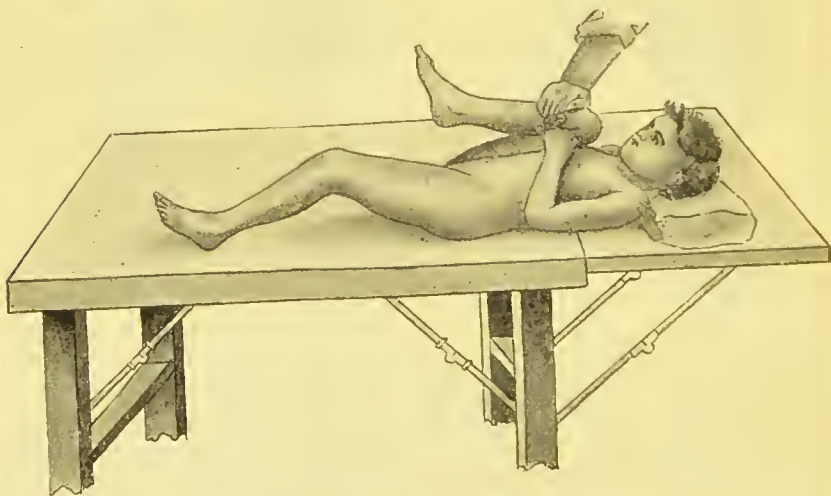


FIG. 286.—Thomas' Flexion Test, showing angle of flexion at diseased (left) hip.

usually so pronounced that it can no longer be concealed by lordosis, so that when the patient is recumbent, although the spine is arched forwards, the limb is still flexed both at

the hip and at the knee; with the spine flat on the table, the flexion of the thigh may amount to as much as a right angle. The *adduction* varies greatly in degree; when it is slight, as is most often the case, the toes of the affected limb rest on the dorsum of the sound foot, as in a traumatic dislocation on to the dorsum ilii. When moderate, it is compensated for by raising the pelvis on the affected side, with *apparent shortening* of the limb, this being the result of an effort on the part of the patient to restore the normal parallelism of the limbs, the sound limb being abducted to the same extent as the affected limb is adducted. It is of great importance to recognise the cause of this shortening, as it can be corrected by treatment. As a result of the obliquity of the pelvis, the patient, when erect, exhibits a lateral curvature of the spine with the dorso-lumbar convexity to the sound side.

When adduction is very pronounced, the patient is unable to restore the normal parallelism of the limbs, and the knee on the affected side may cross the sound limb (Fig. 287). There is a deep groove at the junction of the perineum and thigh, great prominence of the trochanter, and the pelvis may be tilted to such an extent that the iliac crest comes into contact with the lower ribs.

As a result of the pressure of the carious articular surfaces against one another, the acetabulum is enlarged and the upper end of the femur is drawn gradually upwards and backwards within the socket. Examination will then reveal the existence of a variable amount of *actual shortening*; it will also be found



FIG. 287.—Advanced Tuberculous Disease of Left Hip-joint in a girl *æt.* 14, showing flexion, adduction, shortening, and iliac abscess.

that the trochanter is displaced above Nélaton's line, while above and behind the trochanter there is a prominent hard swelling corresponding to the margin of the enlarged acetabulum.

There may, therefore, be a combination of real and of apparent shortening together amounting to several inches (Fig. 287).

In cases of long standing, the shortening is still further added to by deficient growth in length of all the bones of the limb and by flexion-contracture of the knee.

The most reasonable explanation of the attitudes assumed in hip disease is that given by König. If the patient walks without crutches, as he is usually able to do at an early stage of the disease, the attitude of abduction, eversion, and slight flexion enables him to save the limb to the utmost extent; on the other hand, if he uses a crutch, as he is obliged to do at a more advanced stage, he no longer uses the limb for support, but draws it upwards and inwards into the position of adduction, inversion, and greater flexion. Similarly, if he is confined to bed, he lies on the sound side, and the affected limb sinks by gravity so as to lie over the normal one in the position of adduction, inversion, and flexion. König's explanation accords with the fact that in the exceptional cases which begin with adduction and inversion we have usually to deal with a severe type of the disease, associated with grave osseous lesions—precisely those cases in which the patient is compelled from the outset to lie up or to adopt the use of crutches. Further, the transition from the abducted to the adducted position is usually associated with such an aggravation of the symptoms that the patient is no longer able to walk without the assistance of a crutch.

During the third stage the other signs and symptoms become more pronounced; the patient looks ill and thin, he is usually unable to leave his bed, his sleep is disturbed by startings of the limb, and the rigidity of the joint and the wasting of the muscles are very marked. The temperature may rise slightly after examination of the limb, or after a railway journey, or from abscess formation. Marked elevation of the temperature, apart from septic complications, usually indicates the development of tubercle elsewhere, and it may be of general tuberculosis.

Abscess Formation in Hip Disease.—The formation of abscess is not related to any particular stage of the disease, it may occur before there is any deformity, or it may be deferred until the disease has apparently undergone cure. Its im-

portance lies in the fact that if a mixed infection with pyogenic organisms occurs, the gravity of the condition is greatly increased, the patient being exposed to all the risks of septic poisoning.

An abscess may appear *in the thigh* in front of or behind the joint.

The *anterior abscess* usually comes to the surface on one or other side of the psoas muscle. From the resistance offered by the fascia lata, the pus may gravitate down the thigh before perforating the fascia and pointing. It has occasionally happened that when such an abscess has been opened and become septic, the femoral vessels have been eroded, and serious or even fatal hæmorrhage has resulted. The *posterior abscess* develops in the gluteal region, and may make its way to the surface through the gluteus maximus; more often it points at the lower border of this muscle in the region of the great trochanter, or it may gravitate down the thigh.

Abscesses which form *within the pelvis* originate either in connection with the acetabulum or in relation to the psoas muscle where it passes in front of the joint. Those that are directly connected with disease of the acetabulum may remain localised to the lateral wall of the pelvis, or may spread backwards towards the hollow of the sacrum. They may open into the bladder or rectum, or may ascend into the iliac fossa and point above Poupart's ligament, or descend towards the ischio-rectal fossa. The abscess which develops in relation to the psoas muscle may be shaped like an hour-glass, one sac occupying the iliac fossa, the other filling up Scarpa's triangle, the two sacs communicating with each other through a narrow neck beneath Poupart's ligament.

So long as the skin is intact, the abscess is unattended with any symptoms, and may escape notice. If it bursts externally, septic infection is almost inevitable; and if the opening is insufficient for drainage, there occur repeated attacks of inflammation attended with fever, burrowing of pus, and the formation of fresh sinuses. The patient gradually passes into the condition of hectic fever or chronic septic poisoning; he loses ground from day to day, may become the subject of waxy disease in the viscera, or may die of exhaustion, tuberculous meningitis, or general tuberculosis. The presence of septic sinuses is not incompatible with recovery, but they are a source of danger to which the patient should not be exposed if he comes under treatment with unbroken skin.

Dislocation is a rare complication of hip disease, and is most

likely to occur during the stage of adduction with inversion. It has been known to take place during sleep from spasmodic contraction of muscles. In the dorsal dislocation, which is the most common form, adduction and inversion are pronounced, the trochanter projects above and behind Nélaton's line, and the head of the bone may be felt on the dorsum ilii. It is a striking fact that after dislocation has occurred there is less complaint of pain or of startings than before, and passive movements may be carried out which were previously impossible.

Diagnosis of Hip Disease.—The diagnosis is to be made not only from other affections of the joint, but also from morbid conditions in the vicinity of the hip, as in any of these the patient may seek advice on account of pain and a limp in walking. The patient should be stripped, and if able to walk, his gait should be observed. He is then examined lying on his back, and attention is directed to the comparative length of the limbs, to the attitude of the limbs and pelvis, and to the movements at the hip-joint, especially those of rotation. When there is any doubt as to the diagnosis, the examination should be repeated at intervals of a week or ten days. In children, there are three non-febrile conditions attended with a limp and with shortening of the limb, which may be mistaken for hip disease,—*congenital dislocation*, *coxa vara*, and *infantile paralysis*,—but in all of these the normal movements are less restricted than in disease of the joint, and the history is different.

In tuberculous disease of the *sacro-iliac joint*, while the pelvis may be tilted, and the limb apparently lengthened, the movements at the hip are retained. In tuberculous disease of the *great trochanter*, or of either of the *bursæ* over it, the resemblance to hip disease is very close, there may be abduction, eversion, impairment of mobility, and swelling in the region of the trochanter followed by abscess formation, but the movements are less restricted than in disease of the joint.

In *psoas abscess* associated with spinal disease, or in *disease of the bursa underneath the psoas*, the limb is flexed and everted, there may be lordosis, and the patient may walk with a limp. The movements at the hip are restricted only in the directions of extension and inversion, while in hip disease they are restricted in all directions.

New-growths in the vicinity of the hip—especially commencing sarcoma of the upper end of the femur—may be very difficult to differentiate from hip disease. In sarcoma there is no rigidity at the joint, and skiagrams usually give definite information.

Among other conditions which may simulate hip disease, especially in children, are appendicitis, inflammation of the glands in the groin, staphylococcal disease of the upper end of the femur, and sciatica.

The diagnosis *from other diseases of the hip-joint* is seldom difficult.

Prognosis.—The prognosis in hip disease is more serious than in tuberculosis of other joints, excepting only those of the spine, and it is most unfavourable when there are gross lesions of the bones and infected sinuses, especially in adults who are the subjects of tuberculosis elsewhere, although even these may eventually recover.

Whatever the stage of the disease, recovery is a slow process, and even in early and mild cases it seldom takes place in less than one or two years, and is liable to be attended with some impairment of function. During the process of cure, complications are always liable to occur, and after apparent recovery relapses are not uncommon. When arrested during the initial stage, there may only be a limitation in the range of movement; but when the disease has advanced to the stage in which there is destruction of the articular surfaces, the joint is liable to become ankylosed and the limb shortened. The average shortening amounts to from one and a half to two inches. The formation of abscess, especially within the pelvis, is a serious complication.

In cases which terminate fatally, death usually results from meningeal, pulmonary, or general tuberculosis, or from septic complications and waxy degeneration.

Treatment.—A large proportion of cases recover under conservative treatment, and the functional results are so much better than those following operative interference, that unless there are special indications to the contrary, conservative measures should always be adopted.

Conservative Treatment.—The first essential is to take the weight off the limb and secure its fixation in the attitude of almost complete extension and moderate abduction. When the symptoms of hip disease are well marked, the child is kept in bed in the dorsal position, not even being allowed to sit up, and the limb is extended with a weight and pulley.

Extension by weight and pulley.—The weight employed varies from one to four pounds in children, to ten or more pounds in adolescents and adults, and must be adjusted to meet the requirements of each case. If pain returns after having been relieved, it is due to stretching of the ligaments, and the

weight should be diminished or removed for a time. If there is deformity, the line of traction should be in the axis of the displaced limb until the deformity is got rid of. If there is a greater degree of abduction than is ultimately desired, extension is applied to both limbs, and if there is adduction it may be necessary to apply counter-extension by means of a perineal band. The extension should be continued until pain, tender-

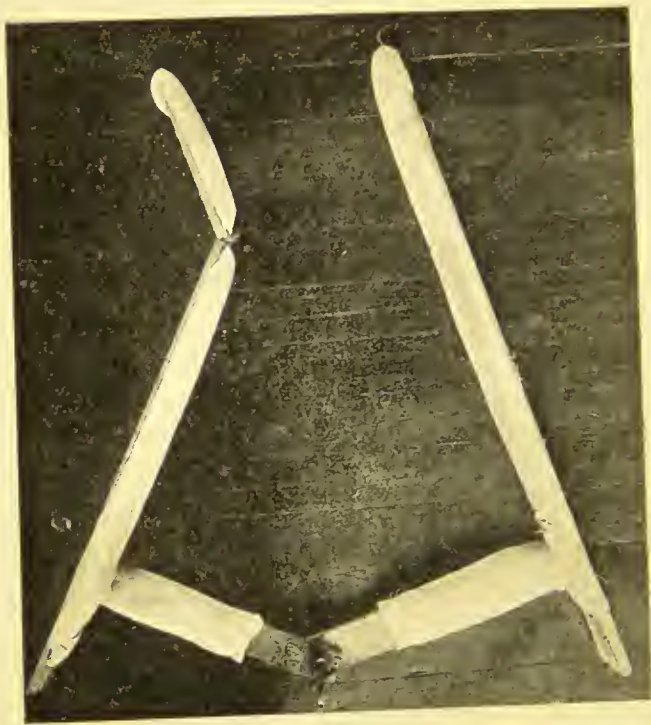


FIG. 288.—Double Long Splint to admit of abduction of diseased limb.
(Photograph by Mr. Lewis Beesly.)

ness, and muscular contraction have disappeared, and the limb has been brought into the desired attitude.

In restless children, in addition to the extension, a long splint is applied on the sound side and a sand-bag on the affected one; or, better still, a double long splint and cross-bar, the long splint on the affected side being furnished with a hinge opposite the hip to permit of varying the degree of abduction (Fig. 288).

When the deformed attitude does not yield rapidly to

extension, it should be corrected under an anæsthetic, and if the adductor tendons and fasciæ are so contracted that this is difficult, they should be forcibly stretched or divided.

Ambulant Treatment.—When the patient is able to use crutches, the affected limb is prevented from touching the ground by fixing a patten on the sole of the boot on the sound



FIG. 289.—Thomas' Hip-splint applied for disease of Right Hip.
Note patten under sound foot.

side. The hip-joint is kept rigid in the abducted position by a Thomas' (Fig. 289) or a Taylor's splint, or a plaster-of-Paris case. The Thomas' splint must be fitted to the patient under the personal supervision of the surgeon, who must make himself familiar with the construction of the splint and its alteration by means of wrenches. Plaster-of-Paris is used chiefly in hospital out-patients who cannot be kept under proper supervision. The case should grasp the pelvis, thigh, and leg, and be moulded

to the tuber ischii and crest of the ilium on either side. It may be strengthened by broad strips of aluminium, and should be renewed at intervals of from six weeks to three months.

In children who are unable to use crutches, a double Thomas' splint, a Phelps's box, or Bonnet's wire cuirass, is employed; by using one of these the child is converted into a rigid object, capable of being carried from one room to another and into the open air. Personally we have obtained most satisfaction from the double Thomas' splint intended for spinal disease, which extends from the occiput to the soles of the feet.

The fixation of the hip-joint and the taking of the weight off the limb by one or other of the above methods, should, as a general rule, be continued for at least a year.

Should an abscess develop, it is treated on the usual lines.

Operative Interference.—Widely diverse opinions are held on the question as to whether or not recourse should be had to operative interference in tuberculous disease of the hip.

Some surgeons, notably Howard Marsh, Robert Jones, and Anthony Bowlby, are strongly opposed to operative interference, on the grounds that however advanced the disease may be it will yield to conservative measures if judiciously and perseveringly carried out. Others, notably Kocher, Carrè, and Stiles, advocate operative treatment in all cases which do not speedily show improvement under conservative treatment. An intermediate attitude may be adopted which recommends operation in cases in which the disease progresses in spite of conservative treatment, and in which periodic examination with the X-rays shows that there are progressive lesions in the upper end of the femur or in the acetabulum.

Nature of the Operative Interference.—The object is to expose the disease wherever situated, and to remove it with the least possible damage to the normal structures; the more open the method of operation, the better. These indications are best fulfilled by the operation devised by Kocher, which, by permitting of dislocation of the head of the femur, affords free access to all parts of the joint. If it is found that the disease in the head is limited to the surface, it may be got rid of with the spoon or gouge, thus preserving the head, which is returned to the acetabulum. If, on the other hand, the head and neck of the bone are more extensively diseased, the neck is divided with a wire saw or a chisel, and the diseased portion removed. The disease in the acetabulum and soft parts having been got rid of with the spoon and scissors, the raw surface of

the neck or upper end of the trochanter is implanted in the socket.

After operation, the limb is fixed in an attitude of marked abduction, so that when the patient resumes the erect posture he will be obliged to depress the pelvis on the affected side to restore the parallelism of the limbs, and will so compensate, in part at least, for the shortening caused by the operation.

Amputation for tuberculous disease of the hip has become one of the rarest of operations, but is still required in cases which have continued to progress after excision, and when there is disease of the pelvis or of the shaft of the femur, with septic sinuses, albuminuria, and hectic fever. In such cases the surgeon must be prepared not only to disarticulate at the hip-joint, but also to remove a portion of, or even the entire innominate bone. Such extensive operations are usually carried out by some form of racket incision, which permits of the ligation of the main vessels as a preliminary measure.

The Correction of Deformity resulting from Antecedent Disease of the Hip.—From neglect or from improper treatment, the deformities already described may have been allowed to persist, while the joint disease has recovered. They are associated either with ankylosis of the joint, or with contracture of the soft parts, or with a combination of these conditions. The contracture of the soft parts involves specially the tendons, fasciæ, and ligaments on the anterior and inner aspects of the joint, and is usually present to such a degree that, even if the joint were rendered mobile, these shortened structures would prevent correction of the deformity. The deformity most often present consists in a combination of shortening, flexion, and adduction.

If flexion is the prominent feature, it may be corrected by performing an osteotomy through the neck of the femur (*Adam's operation*), or through the trochanter if the neck of the bone has disappeared. The contracted soft parts are divided, either by subcutaneous or by open incision, after which the limb is extended and abducted. To a patient whose occupation entails the sitting posture it may be no advantage to have flexion corrected.

If adduction and inversion are the prominent features, the choice lies between a transverse osteotomy below the lesser trochanter (*Gant's operation*), an oblique osteotomy from above downwards and inwards through the great trochanter, or a resection of the joint, according to the special features of the case. If necessary, the adductor muscles, fascia lata, and other

contracted soft parts are divided subcutaneously or by open incision. The limb is then abducted and extended, and maintained in this position by extension with weight and pulley, and by the double long splint already described.

Bilateral Hip Disease.—Both hip-joints may become affected with tuberculous disease, either simultaneously or successively, and abscesses may form on both sides. The patient is necessarily confined to bed, and if the disease is recovered from, his capacity for walking may be seriously impaired, especially if the joints have become fixed in an undesirable attitude. The most striking deformity occurs when both limbs are abducted so that they cross each other,—the “scissor-leg” or “crossed-leg” deformity,—in which the patient, if able to walk at all, does so by forward movements from the knees. An attempt should be made by arthroplasty to secure a movable joint at least on one side.

OTHER DISEASES OF THE HIP-JOINT

Pyogenic Diseases are met with most frequently in childhood and youth, as a result of infection with common pyogenic organisms, gonococci, pneumococci, or typhoid bacilli. While the organisms usually gain access to the tissues of the joint through the blood-stream, a direct infection is occasionally observed from suppuration in the femoral lymphatic glands or in the bursa under the ilio-psoas.

The *clinical features* are sometimes much less striking than might be expected, and are remarkably latent, when the hip affection occurs as a complication of some general illness such as scarlet fever. It may even be entirely overlooked during the active stage, and only at a later period is the head of the femur found to be dislocated, or the joint ankylosed. In the acute arthritis of infants also, the clinical features may be comparatively mild, but as a rule they assume a type in which the suppurative element predominates. The limb usually becomes flexed and adducted, and a swelling forms in front of the joint at the upper part of Scarpa's triangle; the upper femoral epiphysis may be separated.

The flexion and adduction of the limb favour the occurrence of dislocation. A child who has recovered with dislocation on to the dorsum ilii is usually able to walk and run about, but with a limp or waddle, which becomes more pronounced as he grows up. The condition closely resembles a congenital dislocation, but the history, and the presence of gross alteration

in the upper end of the femur as seen with the X-rays, should suffice to differentiate them.

Treatment.—In the acute stage the limb is extended by means of the weight and pulley, and kept at rest with the single or double long splint, or by sand-bags. If there is suppuration, the joint should be opened by an anterior incision inclining downwards and inwards from the anterior superior iliac spine between the tensor fasciæ femoris and the sartorius; a posterior opening being made for drainage. In children, it is remarkable how completely the joint may recover.

If there is dislocation of the femur, it should be reduced by manipulation with or without preliminary extension; it has been successful in about one-half of the cases in which it has been attempted. Preliminary tenotomy of the shortened tendons is required in some cases. When reduction by manipulation is impossible, the joint structures should be exposed by operation and the head of the bone replaced in the acetabulum. When the upper end of the femur has disappeared, the neck should be implanted in the acetabulum, and the limb placed in the abducted position.

Arthritis Deformans. — This disease is comparatively common at the hip, either as a mon-articular affection or simultaneously with other joints.

The changes in the joint are characteristic of the dry form of the disease, and affect chiefly the cartilages and bones. The atrophy and wearing away of the articular surfaces are accompanied by new formation of cartilage and bone around their margins. The head of the femur may acquire the shape of a helmet, a mushroom, or a limpet shell, and from absorption of the neck the head may come to be sessile at the base of the neck, and to occupy a level considerably below that of the great trochanter (Fig. 290). These changes sometimes extend to the upper part of the shaft of the femur, and result in curving of the shaft and neck, suggesting a resemblance to a point of interrogation. The acetabulum may "wander" backwards and upwards, as in tuberculous disease. It is usually deepened, and its floor projects on the pelvic aspect; its margins may form a projecting collar which overhangs the neck of the femur, or grasps it, so that even in the macerated condition the head is imprisoned in the socket and the joint locked. There is eburnation of the articular surfaces similar to that seen in other joints.

These changes are necessarily associated with great restriction

of movement, and with striking deformity, which consists in shortening of the limb, usually with eversion and displacement of the trochanter upwards and backwards in relation to Nélaton's line.

The *clinical features* are usually so characteristic that there is little difficulty in diagnosis. Restriction of the movements of abduction and adduction, the presence of cracking

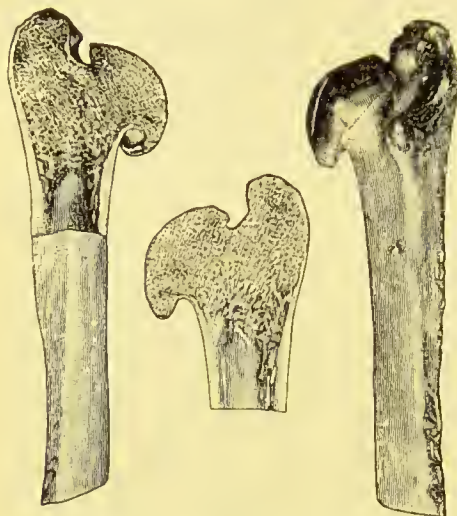


FIG. 290.—Upper End of Femur in advanced Arthritis Deformans of Hip, showing absorption of neck and downward displacement of head of bone.

(Museum of Royal College of Surgeons, Edinburgh.)

and of grating of the articular surfaces, and the aggravation of the pain and stiffness after resting the limb, are characteristic of arthritis deformans. The prominence of sciatic pain may lead to the disease being regarded as sciatica.

The greatest difficulty is met with in cases in which the disease occurs as non-articular affection in adolescents, for the resemblance to tuberculous disease of the hip and to coxa vara may be very close. Skiagrams do not always suffice to differentiate between them.

The local *treatment* is for the most part palliative, and consists in attempting to maintain the normal movements of the joint, and to diminish the pressure on the articular surfaces by the use of sticks or crutches in walking.



FIG. 291.—Upper end of Femur in advanced Arthritis Deformans of Hip. The shaft is curved, and the head of the bone is at a lower level than the great trochanter.

(Anatomical Museum, University of Edinburgh.)

Shortening of the limb may be compensated for by raising the sole of the boot. Forcible movements of the joint under an anæsthetic do more harm than good. Excision of the joint has in some cases yielded satisfactory results; it is indicated in young patients who are otherwise healthy, and who are unable to walk on account of pain and deformity.

Neuro - Arthropathies. — *Charcot's disease* is usually met with in men over thirty who suffer from *tabes dorsalis*. One or both hip-joints may be affected. Sometimes the first manifestation is a hydrops and a fluctuating swelling in the upper part of Scarpa's triangle. In many of the recorded cases, however, attention has first been directed to the disease by the deformity and limp associated with disappearance of the head of the femur, or by the occurrence of pathological dislocation. The absence of pain and tenderness is characteristic. When dislocation has occurred, the limb is short, and the upper end of the femur is freely movable on the *dorsum ilii*. When both hips are dislocated (Fig. 292), the attitude and gait are similar to those observed in bilateral congenital dislocation. The rotation arc of the great trochanter may be much reduced as a result of the disappearance of the head of the femur. There may be considerable formation of new bone, giving rise to large tumour-like masses in relation to the capsular ligament and the muscles surrounding the joint.

The *treatment* consists in protecting and supporting the joint. When the affection is unilateral, advantage may be derived from a Thomas' or other form of splint, along with a patten and crutches; in bilateral cases, from the use of crutches alone.

Hysterical affections of the hip have already been described.

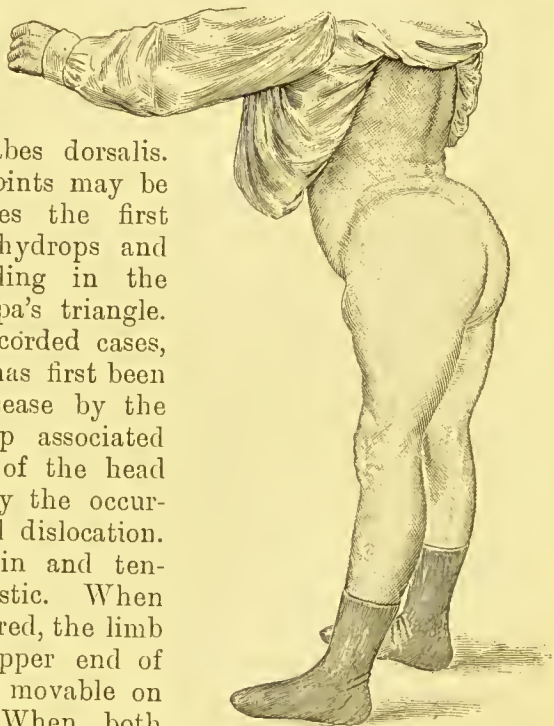


FIG. 292. — Bilateral Charcot's Disease of Hip, with Dislocation of head of femur on to dorsum ilii.

(Dr. H. G. Langwill's case.)

THE KNEE-JOINT

The knee is more often the seat of disease than any other joint in the body.

The synovial membrane extends beneath the quadriceps extensor as a cul-de-sac, which either communicates with the suberural bursa, or forms with it one continuous cavity. When the joint is distended with fluid, this upper pouch bulges above and on either side of the patella, and this bone is "floated" off the condyles of the femur. When there is only a small amount of fluid, it is most easily recognised while the patient stands with his feet together and the trunk bent forwards at the hip-joints, and the quadriceps completely relaxed; the fluid then bulges above and on each side of the patella, and its presence is readily detected, especially on comparison with the joint of the other side.

On account of the great extent of the synovial membrane, a large quantity of serous effusion may accumulate in the joint in a comparatively short time, as a result either of injury or disease. The villous processes and fringes may take on an exaggerated growth, and give rise to pedunculated and other forms of loose body.

The bursæ in the popliteal space, especially that between the semi-membranosus and the inner head of the gastrocnemius, as well as the suberural bursa, frequently communicate with the synovial cavity of the knee and may share in its diseases.

As the epiphyses at the knee are mainly responsible for the growth in length of the lower extremity, and are late in uniting with their respective shafts, serious shortening of the limb may result if their functions are interfered with by disease or injury. The epiphyseal cartilages lie beyond the limits of the synovial cavity, so that infective lesions at the ossifying junctions are less likely to spread to the joint than is the case at the hip or shoulder, where the epiphyses lie partly or wholly within the joint; disease in the lower end of the femur is more likely to implicate the knee-joint than disease in the upper end of the tibia.

TUBERCULOUS DISEASE

While tuberculous disease of the knee is specially common in childhood and youth, it may occur at any period of life, and is not uncommon in patients over fifty. The disease originates

in the synovial membrane and in the bones respectively with about equal frequency.

When the synovial membrane is diseased, it tends to grow inwards over the articular surfaces (Fig. 293). In the femur this usually takes place from the lateral margins of the condyles at the level of the lower edge of the patella, often shutting off the supra-patellar pouch and fixing the kneecap to the femur. In the case of the tibia and patella the synovial membrane grows in from the margins, diminishing the area of their articular surfaces. The ingrowth of synovial membrane may fill up the entire cavity of the joint, or may divide it up into

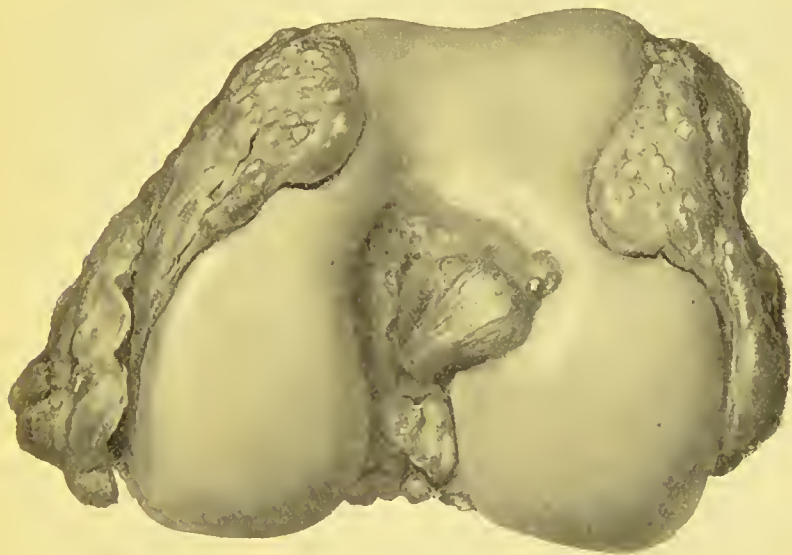


FIG. 293.—Tuberculous Synovial Membrane of Knee, spreading over articular surface of femur.

compartments, one usually being above the patella, and two in relation to the condyles of the femur. When, under these conditions, a tuberculous focus in the bone erupts into the joint, the infection may be confined to one or other of these compartments. Ulceration of the cartilage and caries of the articular surfaces are commonly met with.

The femur and tibia are affected with about equal frequency, and the nature and seat of the bone lesions are subject to wide variations. Multiple small foci may be found beneath the articular cartilage of the tibia, or along the lateral margins of the femoral condyles—especially the internal. Cascading foci are comparatively rare, but they sometimes attain a considerable

size—especially in the head of the tibia, where they may assume the character of a caseous abscess. Sclerosed foci, which may form sequestra, are comparatively common (Fig. 294). Diffuse caseating osteomyelitis may involve an entire epiphysis and extend into the adjacent shaft.

Clinical Types of Tuberculous Disease of the Knee.—(1) *Hydrops tuberculosis* is that type in which the outstanding feature is the accumulation of fluid in the joint. It usually arises from a purely synovial lesion, but when the joint suddenly becomes distended with fluid, it is usually the result of the rupture of an osseous focus into the joint.

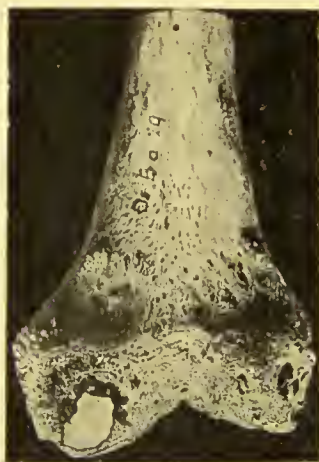


FIG. 294.—Lower End of Femur from an advanced case of Tuberculous Arthritis of the Knee. Towards the posterior aspect of the internal condyle there is a wedge-shaped sequestrum, of which the surface exposed to the joint is polished like porcelain.

(Anatomical Museum, University of Edinburgh.)

It is met with chiefly in young adults. As a rule, the fluid accumulates gradually and imperceptibly, stretching the capsule, and pushing the patella forwards, so that it floats. There is little pain or interference with the functions of the joint; the patient is usually able to walk, but is easily tired. The amount of fluid diminishes under rest, and increases after use of the limb. In a certain number of cases it may be possible to recognise some thickening of the synovial membrane, or the presence of friction or crepitation from the mutual contact of floating masses of fibrin or melon-seed bodies. This is best appreciated if the knee is alternately flexed and extended by

the patient while the surgeon grasps and compresses it with both hands. If the joint is opened, fibrinous material, often in the form of melon-seed bodies, may be found lining the synovial membrane and partly covering the articular surfaces. Melon-seed bodies may be found in the fluid withdrawn from the joint.

Tuberculous hydrops is to be diagnosed from the effusion which results from repeated sprain, from the hydrops of loose body, gonorrhœa, arthritis deformans, Charcot's disease, and Brodie's abscess in an adjacent bone, and from the hæmarthrosis met with in bleeders.

Tuberculous hydrops is specially amenable to treatment by rest, hyperæmia, and injections of iodoform. Relapse, however, is not uncommon, and experience shows that if the disease is neglected, there may be a gradual transition to the graver types of synovial tuberculosis.



FIG. 295.—Advanced Tuberculous Disease of Knee, with backward displacement of Tibia.

(2) *Papillary or Nodular Tubercle of the Synovial Membrane.*
—This is a condition in which there is a fringy, papillary, or polypoidal growth from the synovial membrane. It is most often met with in adult males between the ages of twenty and forty. The onset and progress are gradual, and the chief com-

plaint is of stiffness and swelling which are worse after exertion. Sometimes there are symptoms of loose body, such as occasional locking of the joint, with pain and inability to extend the limb; but the locking is easily disengaged, and the movements are at once free again. The patient may give a history of several years' partial and intermittent disability, with lameness and occasional locking, although he may have been able to go about or even to continue his occupation.

There is a moderate degree of effusion into the joint, and when this has subsided under rest it may be possible to feel ill-defined cords, or tufts, or nodular masses, and to grasp between the fingers those in the supra-patellar pouch. There is little wasting of muscles, and it is quite exceptional to have any signs of disease of the articular surfaces or of the formation of a cold abscess.

On opening the joint, there may escape fluid and loose bodies similar to those described under hydrops, and if the finger is introduced into the cavity, the upper pouch is felt to be occupied by fringes or polypoidal processes derived from the synovial membrane.

The diagnosis is to be made from arthritis deformans, and in some cases from loose body of other than tuberculous origin.

The treatment specially applicable to this type is to open the joint and remove the diseased synovial membrane.

(3) *Cold abscess* or *empyema* of the knee is a rare condition, in which the joint becomes filled with pus. It usually results from a primary tuberculosis of the synovial membrane occurring in one much reduced in health, and the subject of tuberculosis elsewhere. While usually insidious in its development and progress, an acute form attended with fever is met with in children. The treatment consists in withdrawing the pus, and injecting iodoform.

(4) *Diffuse Thickening of the Synovial Membrane—White Swelling.*—So long as this form of the disease remains confined to the synovial membrane, the chief feature is that of an indolent elastic swelling in the area of the joint. The swelling tapers off above and below, so that it acquires a fusiform shape, and from the wasting of the muscles it appears greater than it really is. The range of movement is restricted.

At first the patient limps, keeps the knee slightly flexed, and complains of tiredness and stiffness after exertion. As time goes on, the articular surfaces become affected and more severe symptoms ensue. There is pain, which is readily

excited by jarring of the limb or by any attempt at movement; the joint is held rigid, and there may be startings at night which interfere with sleep. If untreated, flexion becomes more pronounced—it may be to a right angle—the leg and foot are rotated outwards, and, in children, the tibia may be displaced backwards (Fig. 295). The wasting of muscles continues, the part becomes hot to the touch, the swelling increases, and may show areas of softening or fluctuation from abscess formation.

White swelling is to be differentiated from peri-synovial gummata, from myeloma and sarcoma of the lower end of the femur, and from bleeder's knee. In the first of these the swelling is nodular and less uniform, and there may be tertiary ulcers or depressed scars in the neighbourhood of the patella. In tumours the swelling is more marked on one side of the joint, it is uneven or nodular, it does not correspond to the shape of the synovial membrane, and may extend beyond the limits of the joint, and it involves the bone to a greater extent than is usual in disease of the joint. Skiagrams show expansion of the bone in central tumours, or abundant new bone in ossifying sarcoma. In difficult cases, recourse should be had to exploratory incision. The diagnosis of bleeder's knee is to be made chiefly from the history.

(5) *Primary Tuberculous Disease in the Bones of the Knee.*
—So long as the foci are confined to the interior of the bone, it is impossible to recognise their existence, unless they are of sufficient size to cause enlargement of the bone or to be discernible in a skiagram.

(a) If the focus reaches the surface of the bone *outside the limits of the synovial membrane*, there is tenderness on pressure, pain in walking, and probably a limp, and a cold abscess may develop. The joint, although perhaps a little sensitive and restricted in its movement, and in some cases the seat of a serous effusion, may not itself become infected with tubercle.

(b) If the focus *reaches the surface of the bone where it is covered by articular cartilage*, the latter is perforated or detached, and the joint becomes infected. The symptoms vary with the nature of the perforation and the amount of infective material thrown into the joint. The resulting joint disease may evolve gradually and assume the characters of a dry arthritis, with pain, rigidity, and tendency towards fibrous ankylosis, or it may develop suddenly and progress rapidly towards suppuration and disorganisation of the joint. Tuberculous caries of the articular surfaces without white swelling

is to be differentiated from arthritis deformans and from hysterical knee.

(c) If the focus reaches the surface of the bone *at the level of the reflection of the synovial membrane*, the membrane becomes thickened at the site of infection in the first instance, but as time goes on it becomes infected throughout, just as in primary synovial disease.

The formation of extra-articular abscess in tuberculous disease of the knee takes place in rather more than fifty per cent. of cases. Abscesses may originate in the substance of the synovial membrane, within the synovial cavity or in one of its compartments, in the surrounding cellular tissue, or in relation to one of the bursæ in the popliteal space. When left to themselves, such abscesses tend to spread up the thigh, or down the back of the leg between the superficial and deep layers of calf muscles, and numerous sinuses may result from their rupture through the skin.

Attitudes of the Limb in Knee-Joint Disease.—The attitude most often assumed is that of *flexion*, with or without *external rotation of the leg and foot*. The flexion is explained by its being the resting attitude of the joint, and that which affords most ease and comfort to the patient. Once the joint is flexed, the involuntary contraction of the flexor muscles maintains the attitude, and if the patient is able to use the limb in walking, the weight of the body is a powerful factor in increasing it. The external rotation of the leg is probably associated with contraction of the biceps muscle. *Backward displacement of the tibia* is met with chiefly in neglected cases of chronic disease of the knee when the patient has walked on the limb after it has become flexed.

In certain cases, *genu valgum* or abduction of the leg is present along with a slight degree of flexion. The valgus attitude is associated with slight outward displacement of the patella, with prominence and apparent enlargement of the internal condyle, with depression of the pelvis on the diseased side and apparent lengthening of the limb.

Treatment of Tuberculous Disease of the Knee.—Conservative measures are indicated when there is a prospect of obtaining a movable joint. When the articular surfaces are so involved that this is no longer possible, in adults it is a waste of time and a possible source of danger to persist with conservative measures. By operation, one may reasonably promise cure of the disease within a definite time, and although the knee is stiff, the limb is a useful one. In children, it is

seldom necessary to have recourse to operation, because they have greater recuperative powers, and because time is of secondary importance; moreover, operations on the bones tend to interfere with the growth of the limb.

Conservative Treatment.—The limb is immobilised in the position of almost complete extension, and one or other of



FIG. 296.—Thomas' Knee-splint applied. Note extension strapping applied to affected leg, and patten under sound foot.

the methods of inducing hyperæmia diligently employed. If the joint is sensitive and tends to be flexed, the patient is confined to bed, the limb secured to a posterior splint, and extension with weight and pulley applied to the leg. If there is no pain or tendency to flexion, or when these have been overcome, the limb is put up in a Thomas' splint (Fig. 296) and the patient allowed to go about. The splint is worn for a period varying from six to twelve months; before being dis-

carried altogether it may be left off at night; it is ultimately replaced by a bandage.

The injection of iodoform is more easily carried out than in other joints; the needle is introduced either into the upper pouch or into the interval between the bones on the inner side of the ligamentum patellæ.

The indications for *operative treatment* are: (1) Marked symptoms of destruction of the articular cartilages; (2) a deformed attitude incapable of being rectified without operation; (3) a condition of the general health which requires that the disease should be got rid of by the most rapid method; (4) progress or persistence of the disease in spite of conservative treatment.

In patients under fifteen years of age, the operation consists in removing the tuberculous synovial membrane, and if the articular surfaces are affected, paring them with a strong knife—arthrectomy. Above the age of fifteen, the ends of the bones are removed with the saw, and the soft structures with the knife or seissors—excision.

Amputation is performed irrespective of age when the disease has relapsed after excision and there is persistent suppuration, and when life is threatened by the occurrence of tuberculosis in the lungs or elsewhere.

Treatment of Deformities resulting from Antecedent Disease of the Knee.—When the articular surfaces are fairly preserved, and the flexion is due to contracture of the posterior part of the capsule and other structures in the popliteal space, these should be divided through an oblique incision made from above downwards across the space; the tendons are split longitudinally and lengthened. If forcible correction is attempted without cutting, it must be carried out by degrees. When there is fibrous or osseous ankylosis in the flexed position, the choice lies between arthroplasty and the removal of a wedge of bone. In patients who are still growing, it may be possible to straighten the limb by dividing or taking a wedge out of the femur above the epiphysial junction. The alternative is to wait until the patient is nearly full grown, and then remove a wedge including the articular ends of the bones.

OTHER DISEASES OF THE KNEE-JOINT

Pyogenic diseases result from infection through the blood-stream, from the spread of infection from one of the adjacent bones, or from a penetrating wound of the joint. The com-

moner types include the *serous synovitis* associated with disease in the adjacent bone, *acute arthritis of infants*, joint suppuration in *pycemia*, *septic arthritis* following upon penetrating wounds, and the affections which result from *gonorrhœal* or *pneumococcal* infection.

Treatment.—The limb is immobilised on a Watson's posterior splint so padded as to allow slight flexion at the knee, and hyperæmia is induced by one or other of the methods devised by Bier. To tap the joint, the needle is introduced obliquely into the supra-patellar pouch, and if it is necessary to open and drain the joint, the incision is made on one or on both sides of the patella. Even then the infection may continue to progress and threaten the life of the patient, and under these conditions it may be necessary to lay the joint freely open from side to side by dividing the patellar ligament and capsule, or sawing across the patella; the limb is flexed, the whole wound left open and packed with gauze. It is sometimes necessary to make additional incisions over the back of the condyles to drain the large synovial pouches which lie behind the crucial ligaments. As the infection subsides, the limb is gradually straightened. If these methods fail, amputation through the thigh is to be had recourse to.

Arthritis deformans may affect the knee alone or in combination with other joints. The changes related to the synovial membrane attain their maximum development in this joint, and may assume the form of hydrops with or without fibrinous bodies, or of overgrowth of the synovial fringes and the formation of pedunculated loose bodies. Fibrillation of the cartilage imparts a feeling of roughness when the joint is grasped during flexion and extension, and lipping of the margins of the trochlear surface of the femur may be felt when the joint is flexed. When a portion of the "lipping" is broken off, it may give rise to the symptoms of loose body. In advanced cases with destruction of the cartilages, there may be lateral movement with grating of the articular surfaces.

In hydrops, the joint may be tapped and iodoform injected. When the symptoms are due to the presence of hypertrophied fringes and loose bodies, these may be removed by operation. When the disease is of a severe type and is confined to one knee, the question of excising the joint may be considered.

Bleeder's knee, *Charcot's disease*, *hysterical knee*, and *loose bodies* in the joint have been described in the chapter on Diseases of Joints.

THE ANKLE-JOINT

There is a common synovial cavity for the ankle and the inferior tibio-fibular joints. The epiphysial cartilage of the tibia lies above the level of this synovial cavity, but that of the fibula is included within its limits (Fig. 225). The astragalus is related to three articulations—the ankle above, the astragalo-scaphoid joint in front, and the calcaneo-astragaloid joint below. The tendon sheaths, especially those of the peronei and of the tibialis posticus, are liable to be infected by the spread of infective disease from the joint.

Tuberculous Disease.—Tuberculous disease at the ankle is met with at all ages. In the majority of cases it commences in the synovial membranc. Gross lesions in the bones are comparatively rare, and are more often met with in the astragalus than in the articular ends of the tibia and fibula.

Primary synovial disease usually exhibits the features of white swelling, projecting beneath the extensor tendons on the dorsum, and, posteriorly, filling up the hollows on either side of the tendo Achillis and below the malleoli (Fig. 297). The foot may retain its normal attitude, or the toes may be pointed and adducted. The calf muscles are wasted, there is little complaint of pain, and the movements of the joint may be so little interfered with that the patient can walk without limping. When the disease has spread to the articular surfaces, there is pain and sensitiveness, the normal movements are restricted or abolished, and the patient is unable to put the foot to the ground.

Primary disease in the bones causes enlargement of one or other malleolus, localised pain and tenderness, and a limp in walking, but the first sign may be the formation of abscess or the rapid development of articular symptoms. In such cases skiagrams afford valuable information.

Abscess formation is an early and prominent feature of disease of the ankle, whether of osseous or synovial origin, and sinuses are liable to form around the joint. Outlying abscesses and sinuses are usually the result of infection of the tendon sheaths in the neighbourhood.

Diagnosis.—When tuberculous teno-synovitis occurs independently of disease of the ankle, the swelling is confined to one aspect of the joint. In sarcoma of the lower end of the tibia, the swelling lacks the uniform distribution of that met with in joint disease. In Brodie's abscess of the lower

end of the tibia there may be swelling of the ankle, but there is an area of special tenderness on percussion over the bone.

Treatment.—The foot is immobilised at a right angle to the leg by splints or plaster of Paris; if articular symptoms are absent or have subsided, a 'Thomas' knee-splint should be applied to enable the patient to move about without bearing his weight on the affected foot (Fig. 296). To inject iodoform,



FIG. 297.—Tuberculous Disease of Synovial Membrane of Left Ankle in a girl æt. 15.

the point of the needle is inserted below either malleolus, and is then pushed upwards alongside of the astragalus. If localised disease in one of the bones is recognised before the joint is infected, it should be eradicated by operation.

When the disease is diffuse and resists conservative treatment, arthrectomy or excision should be performed, the articular surfaces of the constituent bones being removed, and if necessary the whole of the astragalus.

Amputation is only called for in adults with rapidly pro-

gressing disease and diffuse suppuration, and in cases which have relapsed after excision.

The other diseases of the ankle include *pyogenic*, *gonorrhœal*, *rheumatic*, *gouty*, and *hysterical* affections, *arthritis deformans*, and *Charcot's disease*. The last-named is generally associated with a rapid and painless disintegration of the bones of the ankle and tarsus, resulting in great deformity and loss of the arch of the foot—sometimes associated with perforating ulcer of the sole.

Tuberculous disease in the **tarsus**, **metatarsus**, and **phalanges** has been considered in the chapter on Diseases of Bone.

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